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# THEORETICAL IMPLICATIONS OF THE RESPONSE OF A PHOTORECEPTOR TO A FLASH OF LIGHT*

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## 1. INTRODUCTION

Hecht[1] has described a photochemical theory to explain the action of light on the retinal receptors, which may be summarized as follows:

$$\text{LIGHT} \rightarrow \boxed{S \underset{\text{DARK}}{\overset{\text{LIGHT}}{\rightleftharpoons}} P + A;\ L \parallel P + A \parallel \rightarrow T} \rightarrow \text{IMPULSE.}$$

According to this formulation, light decomposes a photosensitive substance ($S$) into photochemical products ($P$ and $A$) which in turn act as catalysts in a secondary (dark) reaction which results in nerve impulses.

Byram[2] has proposed a modification of Hecht's theory, according to which the photosensitive substance ($S$) is converted by light into active photoproducts. These active photoproducts are converted into inactive photoproducts, and the energy change occuring in this part of the process ultimately produces the visual sensation. A thermal reaction utilizes the inactive products to maintain the supply of photosensitive material ($S$).

Jahn[3] has adopted a similar modification of Hecht's theory which may be formulated as follows:

$$\text{Light} \rightarrow S \rightarrow E \rightarrow P + A \rightarrow S \cdots;\ L \| E \| \rightarrow T.$$

This formulation means that the photosensitive substance ($S$) first becomes transformed into $E$ before breaking down into $P$ and $A$. $E$ acts as the catalyst in the secondary reaction.

In the equations that follow, the concentrations of $S$, $E$, and $(A + P)$ are respectively represented by the symbols $s$, $w$, and $x$.

For the purpose of computing the characteristics of the response to a flash of light, it is satisfactory to assume that the chain of reactions $S \rightarrow E$, $E \rightarrow P + A$, and $A + P \rightarrow S$ constitutes a closed system.

In other words

$$s + w + x = a. \qquad (1)$$

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In this equation $a$ is a constant representing the sum total of the concentrations of $S$, $E$, and $A + P$, and also the maximum value for any one of them.

The rates of the reactions in the primary response are as follows:

$$\left(\frac{ds}{dt}\right)_D = \left(\frac{dw}{dt}\right)_F = k_1 I s, \tag{2}$$

$$\left(\frac{dw}{dt}\right)_D = \left(\frac{dc}{dt}\right)_F = k_2 w, \tag{3}$$

and

$$\left(\frac{dx}{dt}\right)_D = \left(\frac{ds}{dt}\right)_F = k_3 x^2. \tag{4}$$

In the above equations the subscript F indicates that the rate is one of formation, and the subscript D indicates dissipation; $k_1$, $k_2$, and $k_3$ are velocity constants. The symbol $t$ represents time.

Jahn has been concerned primarily with such problems as visual acuity and brightness discrimination. He has not traced completely all of the implications of his modification of Hecht's theory for the characteristics of the response of a single photoreceptor to a flash of light. By extending the theory somewhat, it is possible to predict the sequence of impulses in the photoreceptor axon resulting from a flash of light. Electrophysiological studies of this type of response in the Limulus eye have been reported, which make it possible to check the predictions of the theory. For a review of this data reference is made to the original papers.[4, 5, 6]

The major part of this paper will be concerned with the characteristics of the response of a completely dark-adapted photoreceptor to a flash of light which occurs against a background of total darkness.

## II. DERIVATION OF EQUATIONS FOR PREDICTING THE SEQUENCE OF IMPULSES

According to Jahn's proposal, the production of an impulse is dependent upon the presence of the catalyst $E$. Therefore, in order to predict the sequence of impulses resulting from a flash of light, it is necessary to know the changes in concentration of $E$ and $S$ that occur.

Our method of computing the changes in $s$ is based upon the fact that $k_2$ is large with respect to $k_1$. Consequently the value of $w$ at any moment is so small with respect to $s$ and $x$ that it may be neglected. Hence,

$$x = a - s. \tag{5}$$

The total rate of change in $s$, therefore, may be expressed by the following equation:

$$\left(\frac{ds}{dt}\right) = \left(\frac{ds}{dt}\right)_F - \left(\frac{ds}{dt}\right)_D = k_3(a - s)^2 - k_1 I s. \tag{6}$$

Integrating,

$$t = \int_a^s \frac{ds}{k_3(a - s)^2 - k_1 I s} \tag{7}$$

If the values of $k_3$, $(k_1 I)$ and $a$ are known, the concentration of $S$ at any moment following the onset of the flash may be determined from Equation (7). For example, when $a = 100$, $k_3 = 0.014$ and $k_1 I = 0.357$, Equation (7) reduces to

$$t = 0.6796 \log_e \left[\frac{164 - s}{s - 61}\right] - 0.3402. \tag{8}$$

Fig. 1 depicts the changes in $s$ that occur following the onset of a flash for various values of $k_1 I$.

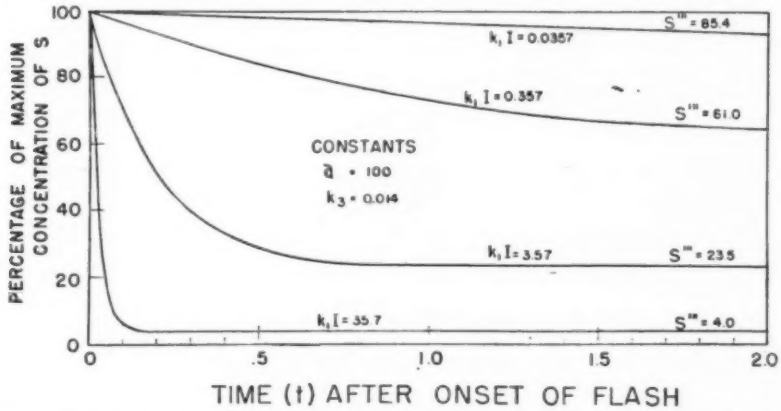



*Fig. 1.* Changes in the concentration of $s$ following the onset of a flash of light for various intensity levels. At each level $s$ approaches an equilibrium value $s'''$. The curves represent plots of Equation (7).

If the flash continues long enough, a state of equilibrium is reached, in which the rate of formation of $S$ is equal to the rate of dissipation; and the concentration of $S$ is maintained at a steady value, $s'''$. The equation for the steady state is as follows:

$$k_3 (a - s''')^2 = k_1 I s'''. \tag{9}$$

In order to plot the curves in Fig. 1, it is necessary to assign definite values to the constants $k_3$ and $a$. The criteria and methods for selecting these and other constants will be described in a subsequent section of this paper.

As already explained, it is justifiable to treat the value of $w$ as negligible when computing $s$, but actually $w$ represents a small finite quantity. The value of $w$ at any given moment following the onset of the stimulus can be determined. Let the time during which the photoreceptor is exposed to light be

divided into small intervals ($\Delta\bar{t}$). Let the time from the onset of the stimulus to the beginning of any one of these intervals be designated by $\bar{t}$. $E$ accumulates during each of these intervals at the rate,

$$\frac{d\bar{w}}{d\bar{t}} = k_1 I s. \tag{10}$$

If $\Delta\bar{w}$ represents the total amount of $E$ accumulated during this interval $\Delta\bar{t}$, it may be determined from the following equation:

$$\Delta\bar{w} = k_1 I s \Delta\bar{t}. \tag{10a}$$

The next step is to find out how much of the original $\Delta\bar{w}$ produced during the interval $\Delta\bar{t}$ remains undissipated at a moment $t$ seconds following the onset of the stimulus. Let the quantity of $E$ that remains from the original $\Delta\bar{w}$ be designated by $\Delta w$.

$E$ dissipates at the rate,

$$\frac{dw}{dt} = -k_2 w. \tag{11}$$

Integrating,

$$\int_{\bar{t}}^{t} dt = \int_{\Delta\bar{w}}^{\Delta w} \frac{dw}{(-k_2)w} = \frac{-1}{k_2} \log_e \frac{\Delta w}{\Delta\bar{w}}. \tag{12}$$

This reduces to

$$\Delta w = \Delta\bar{w} e - k_2(t - \bar{t}). \tag{13}$$

Substituting the value for $\Delta\bar{w}$ found in Equation (10a),

$$\Delta w = e^{-k_2(t-\bar{t})} k_1 I s \Delta\bar{t}. \tag{14}$$

The total concentration of $E$ at any given moment, $t$ seconds after the onset of the stimulus, can be determined by computing the sum of all the $\Delta w$ values for all of $\Delta t$ intervals between the onset of the stimulus and the moment for which $w$ is computed. As $\Delta\bar{t}$ is made to approach zero,

$$\frac{\Delta w}{\Delta\bar{t}} = \frac{dw}{d\bar{t}}, \tag{15}$$

and hence

$$w = \int_{0}^{t} e^{-k_2(t-\bar{t})} k_1 I s \, d\bar{t}. \tag{16}$$

The curves in Fig. 2 which are plotted from Equation (16), depict for various values of $(k_1 I)$, the change in concentration of $E$ as a function of the time following the onset of the stimulus. The curve for $(k_1 I = 3.57)$ in Fig. 3 shows not only the changes in $w$ during the flash but also after the end of the

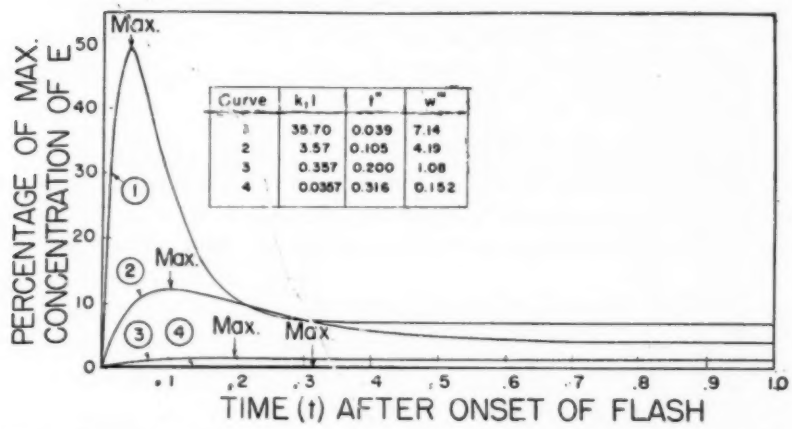

PERCENTAGE OF MAX. CONCENTRATION OF E
TIME (t) AFTER ONSET OF FLASH
Max.
Max.
Max.
Max.
Curve | k1I | t'' | w''
1 | 35.70 | 0.039 | 7.14
2 | 3.57 | 0.105 | 4.19
3 | 0.357 | 0.200 | 1.08
4 | 0.0357 | 0.316 | 0.152

*Fig.* 2. Changes in the concentration of $E$ following the onset of a flash of light for various intensity levels. At each level the concentration ($w$) rises to and reaches a maximum $t''$ seconds after the onset and gradually subsides to a steady value ($w'''$). The curves represent plots of Equation (16). The constant $k_2$ was assumed to be equal to 20.

flash. In each instance the value of $w$ increases to a maximum ($w''$) and then subsides gradually to a steady equilibrium value ($w'''$).

The value of $w'''$ may be determined in a manner similar to that used in the derivation of Equation (6). At the equilibrium condition the rates of formation and dissipation of $E$ are equal.

Hence,

$$k_1 I s''' = k_2 w''', \text{ or } w''' = \frac{k_1 I s'''}{k_2} \quad . \tag{17}$$

When the light goes off, no new $E$ is formed and the amount of $E$ present at the end of the flash is gradually dissipated at the rate,

$$\frac{dw}{dt} = -k_2 w. \tag{18}$$

Let $t$ be the lapse of time in seconds following the onset of the flash and $t''''$ the duration of the flash. Equation (18) can be integrated between the limits $w''''$ and $w$ to determine the value of $w$ at any time following the end of the flash.

$$\int_{t''''}^{t} dt = \int_{w''''}^{w} \frac{dw}{(-k_2)w} = -\frac{1}{k_2} \log_e \frac{w}{w''''} \quad . \tag{19}$$

This reduces to

$$w = w'''' \, e^{-k_2(t - t'''')}. \tag{20}$$

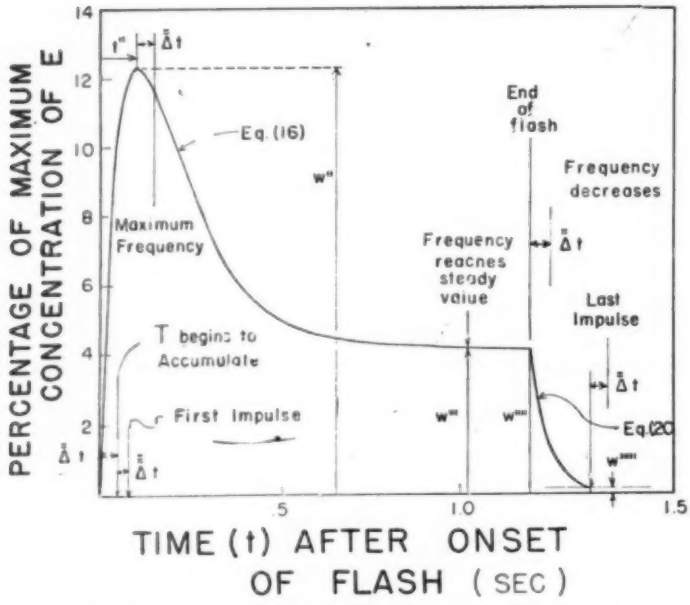



*Fig.* 3. Relation of the sequence of impulses produced by a flash of light to the changes in the concentration of $E$ when $(k_1 I) = 3.57$. The constants which have been used in constructing the figure are as follows:

| | | |
|---|---|---|
| $k_2 = 20$ | $w'''''' = 0.152$ | $k_5 = 1$ |
| $\overline{\overline{\Delta v}} = 30.4$ | $k_4 l = 200$ | $\overline{\overline{\Delta t}} = 0.05$ sec. |

Jahn has assumed that the secondary reaction $(L \rightarrow T)$ proceeds at a rate expressed by the following formula,

$$\left( \frac{du}{dt} \right)_F = k_4 l w. \tag{21}$$

in which $l$ (the concentration of $L$) is assumed to be constant, and $k_4$ is the velocity constant. The symbol $u$ represents the concentration of $T$ at the point of the photolytic reaction.

As will be explained later, it is necessary to assume that $T$ is produced at one part of the photoreceptor but has to diffuse to another part before it can become effective in producing nerve impulses. This process of diffusion requires time and hence there is a lag between the production of $T$ and the arrival of $T$ at the point of nerve stimulation. The rate of diffusion probably depends upon the concentration of $T$ at the various points along the path. Therefore, the rate of arrival of $T$ at the point of stimulation can hardly reproduce the rate of production of $T$ with a fixed time lag between the pairs of moments at which the two rates are equal.

Nevertheless, this is the most convenient assumption to make concerning the rate of arrival of $T$ at the point of stimulation. This rate can be expressed by the equation,

$$\left(\frac{dv}{dt}\right)_F = k_4 l \overline{\overline{w}}. \tag{22}$$

in which $\overline{\overline{w}}$ represents the concentration of $E$ at the point of photolytic action at a given interval of time $\overline{\overline{\Delta}}t$ prior to the moment for which the rate is specified. The symbol, $v$, represents the concentration of $T$ at the point of nerve stimulation.

In order to account for the failure of low intensities to produce a response no matter how long the duration, it is necessary to suppose that $T$ is being constantly dissipated at a slow rate. To illustrate the problem it has been assumed that the rate of dissipation is given by the following equation:

$$\left(\frac{dv}{dt}\right)_D = k_5 v. \tag{23}$$

The value of $v$ at any given moment, $t$ seconds after $T$ begins to accumulate, can be determined by means of the following equation, which can be derived in exactly the same manner as Equation (16):

$$v = k_4 l \int_0^t \overline{\overline{w}}_e - k_5(t - \overline{\overline{t}})d\overline{\overline{t}}. \tag{24}$$

It is further assumed that a given fixed quantity of $T$, $\overline{\overline{\Delta}}v$, must accumulate before the photoreceptor can discharge a nerve impulse.

The reaction time is the total time from the beginning of the flash to the first impulse. It represents the time $(\overline{\overline{\Delta}}t)$ required for $T$ to diffuse from the point of production to the point of use plus the time $(\overline{\overline{\Delta}}t)$ required for $T$ to accumulate in large enough quantity to produce an impulse. (See Fig. 3).

When the photoreceptor discharges, the impulse uses up all of the $T$ which has accumulated. The photoreceptor recovers from its refractory period before any appreciable amount of new $T$ accumulates. Before a second discharge can occur the concentration of $T$ must rise again to the threshold value, $\overline{\overline{\Delta}}v$. The symbol $\overline{\overline{\Delta}}t$ may be used to represent the time for $v$ to rise from zero to $\overline{\overline{\Delta}}v$ for the second and the third impulses and so on, as well as for the first.

The frequency of impulses, $F$, may be determined at any stage of the response by the following equation:

$$F = \frac{1}{\overline{\overline{\Delta}}t}. \tag{25}$$

Equation (24) can be used to determine the value of $\overline{\overline{\Delta}}t$.

In general it may be said that the frequency is proportional to the rate of accumulation of $T$ at the point of nerve excitation.

In the case of a long flash of medium or high intensity, the photoreceptor starts responding before the rate of accumulation of $T$ reaches a maximum. When it reaches a maximum the frequency of impulses is also maximal. This occurs $\overline{\overline{\Delta}}t$ seconds after $w$ reaches a maximum. (See Fig. 3)

After this the frequency steadily declines until it reaches a constant value $F'''$ which is dependent upon the equilibrium concentration of $E$. After $E$ reaches its equilibrium value, $w'''$, Equation (24) which is used for computing $\overline{\overline{\Delta}}t$ reduces to,

$$\overline{\overline{\Delta}}v = \frac{k_4 l w'''}{k_5}(1 - e^{-k_5 \overline{\overline{\Delta}}t}). \tag{26}$$

Solving for $\overline{\overline{\Delta}}t$ and substituting in Equation (25),

$$F = \frac{1}{\overline{\overline{\Delta}}t} = \frac{1}{\log_e\left(\frac{\overline{\overline{\Delta}}v\, k_5}{k_4 l w'''} - 1\right)}. \tag{27}$$

If the frequency is of the order of five per second or higher, Equation (27) reduces further to,

$$F = \frac{1}{\overline{\overline{\Delta}}t} = \frac{k_4 l w'''}{\overline{\overline{\Delta}}v}. \tag{28}$$

When the flash ends, the concentration of $E$ begins to decrease as shown in Fig. 3. As a result the frequency also begins to decrease $\overline{\overline{\Delta}}t$ seconds later.

The photoreceptor stops responding $\overline{\overline{\Delta}}t$ seconds after the concentration of $E$ drops to a critical value ($w''''''$). At this moment the rate of arrival of $T$ at the point of stimulation ($k_4 l w''''''$) becomes equal to $k_5 v'$. When $w$ drops below $w''''''$, $v$ will reach a maximum and start to decrease before it can produce an impulse. The value for $w''''''$ can be computed from the following equation:

$$w'''''' = \frac{k_5}{k_4 l}\overline{\overline{\Delta}}v. \tag{29}$$

Hartline and Graham[4] and Riggs and Graham[6] found in the case of prolonged stimuli that the initial outburst is followed by a short pause or period in which the frequency drops to a much lower level than the final steady frequency which follows. This depression or pause is quite pronounced with high intensities. One method of accounting for the depression would be to treat the concentration of $L$ as a variable. An appreciable part of $L$ could be undergoing transformation to $T$ due to the catalytic action of $E$. At the same time $L$ could be replenished from some external source.

### III. THE RESPONSE TO A LONG FLASH OF THRESHOLD INTENSITY

Since for low intensities $w$ reaches an equilibrium before $v$ reaches its maximum, $v$ gradually rises to its equilibrium value without going through a hypermaximal phase. If the threshold stimulus is defined as one whose equilibrium $v$ value is equal to $\overline{\overline{\Delta}}v$, the reaction time becomes infinite. An equation for the threshold value of $v$ can be derived from Equation (26) by setting $\overline{\overline{\Delta}}t = \infty$.

The equation then reduces to

$$\overline{\overline{\Delta}}v = \frac{k_4 I w'''}{k_5} . \tag{30}$$

If the intensity is raised just above this threshold, a sequence of impulses will result.

A comparison of Equations (29) and (30) brings out the fact that the value of $w'''$ for a threshold stimulus is the same as $w'''''$, the critical value of $w$ at which the photoreceptor stops responding in the case of a strong flash.

### IV. CRITICAL DURATION ($t'$) OF THE STIMULUS FOR THE MINIMUM REACTION TIME

When the stimulus is turned on and left on until after the first impulse, the critical duration is $\overline{\overline{\Delta}}t$ seconds shorter than the reaction time (Fig. 4A). Since $\overline{\overline{\Delta}}t$ represents the time required for $T$ to diffuse from the point of production to the point of nerve stimulation, it is obvious that any $T$ produced later than $\overline{\overline{\Delta}}t$ seconds prior to the response cannot affect the response.

A flash of light whose duration is less than the critical duration presents a special problem. The situation is illustrated by Fig. 4B. During the flash,

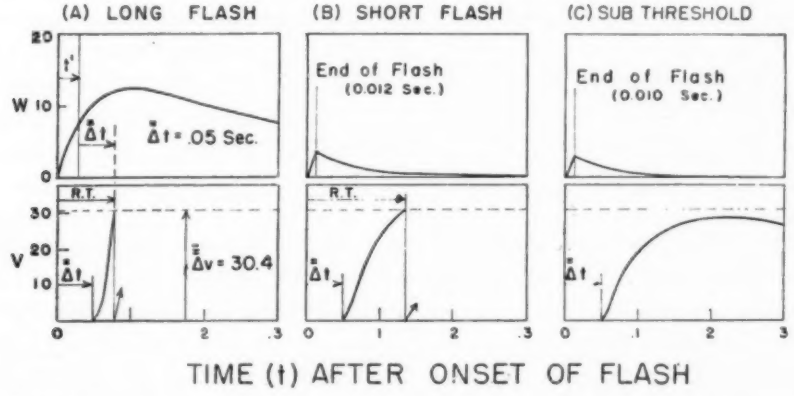



*Fig. 4.* Effect of varying the duration of a flash upon the reaction time (*R.T.*) when $(k_1 I) = 3.57$. The constants which have been used in plotting the curves are the same as for Fig. 3.

the change in the concentration of $w$ can be represented by Equation (16). The $E$ which is present at the end of the flash is gradually dissipated during the period that follows and the amount of $E$ at any moment after the end of the flash is given by Equation (20). As long as any $E$ remains, new $T$ will continue to form. The amount ($v$) of $T$ that will have accumulated at any moment after the onset of the flash is given by Equation (24). The photoreceptor discharges when $v$ reaches the critical value $\overline{\overline{\Delta}}v$.

The figures make it clear why the reaction time lengthens when the duration of the stimulus is reduced below the critical value.

When the flash is too short to produce a response (Fig. 4C), $v$ reaches a maximum and starts to decrease before reaching a value of $\overline{\overline{\Delta}}v$.

### V. CRITICAL DURATION ($t^{III}$) FOR THE MAXIMUM FREQUENCY

Another important feature in the response to a flash of light is the relation of the peak in the $w$-curve to the point in time at which the maximum frequency occurs. When the intensity is high, the critical duration for the minimum reaction time is shorter than the length of time required for $w$ to reach its maximum. This means that after the photoreceptor commences to discharge, the rate of accumulation of $T$ at the point of stimulation continues to increase. The point of maximum frequency occurs $\overline{\overline{\Delta}}t$ seconds after the peak in the $w$-curve. The time from the onset of the stimulus to the peak in the $w$-curve represents the critical duration for maximum frequency. Prolonging the stimulus does not increase the frequency, and reducing the exposure decreases it.

For intensity levels, at and just above the threshold, the critical duration for the minimum reaction time is longer than the time required for $w$ to reach its maximum, and therefore the frequency of impulses begins to decrease with the third impulse, i.e., the interval between the first and second impulse is less than that between the second and third and so on. Under these circumstances the critical duration for the maximum frequency becomes identical with the critical duration for the minimum reaction time.

### VI. SELECTION OF VALUES FOR THE CONSTANTS

In constructing the various figures, the following values have been assumed for the various constants involved in the theory:

$l = 100$ — Threshold value of $k_1 I = 0.0357$

$a = 100$

$k_2 = 20$ — $\overline{\overline{\Delta}}v = 30.4$

$k_3 = 0.0143$

$k_4 = 2$ — $(w^{III})_{\text{threshold}} = 0.152$

$k_5 = 1$

These constants which apply to the Limulus photoreceptor are based upon the electrophysiological records of responses of single photoreceptors as reported by the investigators. The criteria and procedures which have been used in selecting these constants may be described as follows:

It follows from Equation (9) that the equilibrium value of $s$ is fixed so long as $\left(\frac{k_1 I}{k_3}\right)$ is constant. For example, $s$ has an equilibrium value of 23.5 when $\left(\frac{k_1 I}{k_3}\right)$ has a value of 255. It is possible, therefore, for the absolute values of $k_1$ and $k_3$ to vary without affecting the equilibrium value of $s$, just so long as the ratio is constant. The absolute values of $k_1$ and $k_3$ determine the length of time required for $s$ to reach its equilibrium value. A value of 0.0143 has been assigned to $k_3$, because when the value of $\left(\frac{k_1 I}{k_3}\right)$ is 255., $s$ practically reaches its equilibrium value at the end of 0.5 seconds. This corresponds also to the length of time required for the initial outburst of impulses to subside to a steady frequency. This is in reasonable agreement with the facts, since Hartline and Graham[4] found that for medium intensities the initial outburst of impulses subsides to a minimum in about this length of time.

Actually the specification of the value of $k_3$ to the third significant figure is uncalled for because it cannot be determined to this degree of accuracy.

The selection of a value for $k_2$ has been based upon the fact that changing $k_2$ affects the lapse of time from the onset of the stimulus to the moment ($t'''$) at which $w$ reaches its maximum. The value of $t'''$ for any given value of ($k_1 I$) and $k_3$ can be obtained by plotting Equation (16) as shown in Fig. 3. For the higher values of ($k_1 I$), $t'''$ represents the critical duration for the maximum frequency in the initial outburst of impulses. Hartline[5] found that a stimulus approximately ten times as intense as the threshold has a critical duration for the maximum frequency of approximately 0.2 seconds. Accordingly 20 has been selected for $k_2$, because it gives a $t'''$ value of approximately 0.2 for a ($k_1 I$) value of 0.357 which is ten times higher than the assumed threshold. As will be pointed out later, the choice of the threshold value of ($k_1 I$) is somewhat arbitrary and this adds to the inexactness of the value for $k_2$.

In order to select a threshold value for ($k_1 I$), it is necessary to consider the manner in which $w'''$, the equilibrium value of $w$, varies as a function of $k_1 I$. Equation (9) involves a certain amount of error due to the fact that $x$ was assumed to be equal to $(a - s)$ instead of $(a - s - w)$. A more exact equation for $w'''$ can be derived if the exact equivalent of $x$ is used.

At equilibrium,

$$k_1 I s''' = k_2 w''' = k_3 (x''')^2, \tag{31}$$

and

$$a = s''' + w''' + x''' \quad . \tag{32}$$

Solving Equation (31) for $x$ and $s$ in terms of $w$ and substituting in Equation (32) gives:

$$(w''')^2 \left(1 + \frac{k_2}{k_1 I}\right) - w''' \left[2a \left(1 + \frac{k_2}{k_1 I}\right) + \frac{k_2}{k_3}\right] + a^2 = 0 \quad . \tag{33}$$

From this equation, the value of $w'''$ for any value of $k_1 I$ can be determined. A plot of $w'''$ against log $k_1 I$ is shown in Fig. 5. The maximum value which $w'''$ approaches as a limit is 6.28. Hartline and Graham[4] found that at an intensity value 5 log units above the threshold the equilibrium frequency was still increasing with no indication of approaching a maximum. Since the maximum was not determined, the choice of a threshold value for $k_1 I$ is somewhat uncertain, but a value of 0.0357 for $k_1 I$ gives a range of four units in which significant changes in $w'''$ occur. Below 0.0357 there is no significant change in $w'''$.

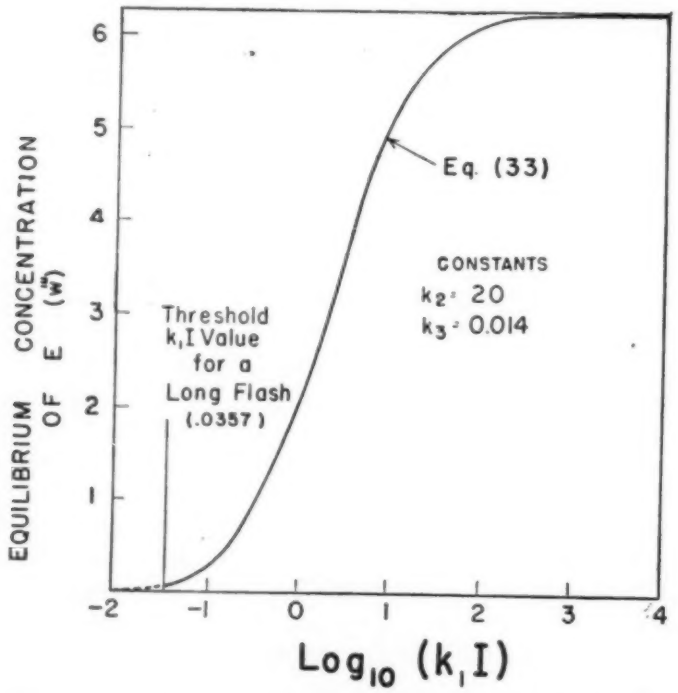



*Fig. 5.* Effect of varying the intensity ($I$) of a flash upon the equilibrium concentration of $E$.

The value of $k_1$ is dependent upon the units in which $I$ is measured. The threshold value of $I$ can be determined by direct experiment.

The $w'''$ value for a threshold $k_1 I$ value can be computed from Equations (9) and (17) and has been found to be 0.152.

A value of 2 has been selected for $k_4$ for convenience of computation and a value of 100 has been assigned to $l$. These two constants always appear as a product and the value is relative to the units in which $l$ and $v$ are measured.

As shown in Fig. 5 one might expect to be able to find a flash of such intensity that further increase in intensity would not increase the equilibrium frequency, $F'''$. It is difficult to determine from the data available the maximum $F'''$ value, but a value of 41 per sec. is approximately correct. As shown in Fig. 5 the maximum value of $w'''$ is 6.28, and therefore it follows from Equation (28) that $\overline{\overline{\Delta}} v = 30.4$.

Since a long flash having a threshold ($k_1 I$) value of 0.0357 has a $w'''$ value of 0.152, the value for $k_5$ can be determined from Equation (30), and has been found to be equal to one.

No attempt has been made to determine the value of $\overline{\overline{\Delta}} t$. For a flash 100 times the threshold level, Hartline[5] found that the time from the beginning of the flash to the maximum frequency is about 0.3 sec. longer than the critical duration. But he also found for higher intensities that the total reaction time is less than .01 sec. Therefore the value of $\overline{\overline{\Delta}} t$ cannot be a constant.

It is most likely that a more satisfactory selection of constants can be made; but the values selected give reasonable agreement between fact and theory, sufficiently so, to merit consideration for the theory.

## VII. LIGHT AND DARK ADAPTATION

It has been assumed that the reaction, $S \rightarrow E \rightarrow P + A \rightarrow S \cdots$, is a closed system in which the sum of the concentrations of all the individual substances present at any moment is a constant, $a$. It seems feasible to ascertain whether or not the facts of light adaptation and dark adaptation can be explained adequately on this basis. The implications of a closed system would be as follows:

1. Bright adaptation consists in the attainment of equilibrium between the concentrations, $w$, $s$, and $x$, for a given intensity.
2. Dark adaptation consists in the recombination of $P$ and $A$ in the dark to form $S$.

Consider first dark adaptation. Assume that the photoreceptor has been pre-exposed to light long enough for the concentration of $S$ to be reduced to

zero. The rate of regeneration of $S$ is given by the following formula:

$$\frac{ds}{dt} = k_2 x^2 \quad . \tag{34}$$

Little error is introduced if we assume, as has been previously done, that

$$x = (a - s) \quad . \tag{35}$$

Hence,

$$\frac{dt}{ds} = \frac{1}{k_3(a - s)^2} \quad . \tag{36}$$

Integrating,

$$t = \frac{1}{k_3} \int_0^s \frac{ds}{(a - s)^2} \quad . \tag{37}$$

This reduces to

$$tk_3 = \frac{1}{a\left(\frac{a}{s} - 1\right)} \quad . \tag{38}$$

Fig. 6 is a plot of Equation (38). Almost complete dark adaptation is achieved in 20 seconds. However, Hartline[5] found it necessary to allow the Limulus eye 20 minutes in the dark to become dark adapted after exposure to a bright flash. This simply means that if the values for the constants, as

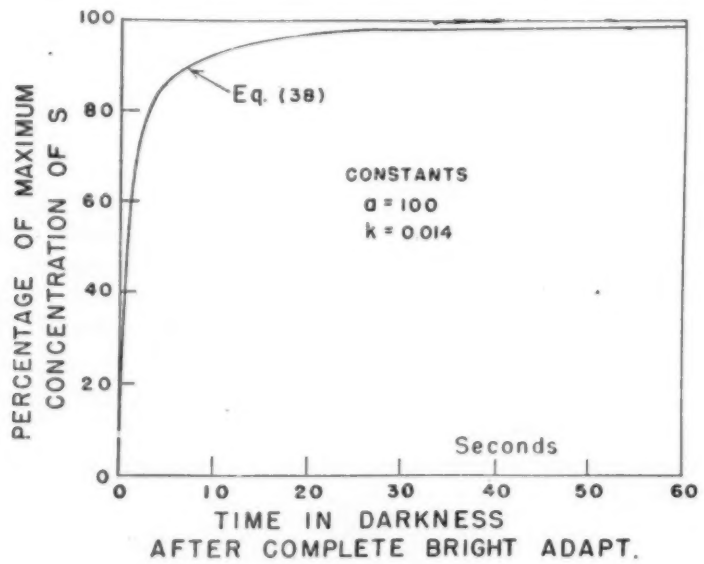
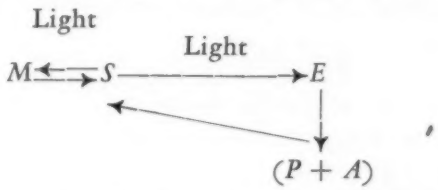



*Fig. 6.* Reconversion of $(A + P)$ to $S$ in darkness.

determined above, are of the correct order of magnitude, dark adaptation cannot be fully accounted for in terms of changes in the percentage concentrations, $s$, $w$, and $x$.

Thus in order to account for the phenomena of light and dark adaptation on the basis of the theory, it becomes necessary to assume that the value of $a$ does not remain constant. There are several possibilities which may account for changes in the value of $a$. A thorough quantitative investigation of these various possibilities is beyond the scope of this paper. All that will be attempted is a brief description of some of these possibilities.

One method of accounting for changes in $a$ is to assume that light starts off two cycles of reactions instead of one. This is indicated as follows:




The one cycle, $S \rightarrow E \rightarrow P + A \rightarrow S \cdots$, is the only one involved in the production of nerve impulses. The other cycle, $S \rightarrow M \rightarrow S \cdots$, produces slow changes in adaptation. Light not only converts part of the photosensitive substance ($S$) to $E$, but also a part of it into $M$. This latter reaction is conceivably reversible. Actually, $M$ may represent one or more substances.

As is shown in Fig. 6, the amount of $E$ and $(P + A)$ in the system after twenty seconds of dark adaptation is negligible, since all the available $E$, $A$ and $P$ have been converted back to $S$. However, the reaction $M \rightarrow S$ could be so slow that all of the $M$ would not be reconverted to $S$ till considerably later.

The process of bright adaptation is more complex. If a dark adapted photoreceptor were suddenly exposed to light, both systems, $S \rightarrow M \rightarrow S$ and $S \rightarrow E \rightarrow P + A \rightarrow S$ would start approaching an equilibrium. However, there is reason to believe that the first system approaches an equilibrium much more slowly than the second.

At threshold intensity ($k_1 I = 0.0357$) the system, $S \rightarrow E \rightarrow P + A \rightarrow S \cdots$, would reach an equilibrium in ten seconds, assuming for the moment that $a$ undergoes little or no change in the meantime. At a high intensity level such as when $k_1 I = 35.7$, only 0.15 seconds are required.

The possibility that the reaction $S \rightarrow M$, is very fast, that is, comparable to that of the reaction, $S \rightarrow E \rightarrow A + P$, is ruled out, because a fast $S \rightarrow M$ reaction would reduce the concentration of $S$ to a very low level. Therefore the $S \rightarrow M$ reaction must be assumed to be very slow.

There is also positive, direct indication that this is the case. Riggs and

Graham[6] found in a study of the response to a long exposure that after the initial outburst of impulses and the "silent period" that follows, the sequence of impulses settles down to a regular stream, but is not constant. It steadily declines and fails to reach a final level after half an hour. This slow decline in frequency could be attributed to a slow change of $S \rightarrow M$.

There are other factors to be considered. The concentration of $L$ is not necessarily constant, and the minimum concentration of $T$ required to produce an impulse may undergo changes.

It is also possible to account for a change in the value of $a$ by supposing that either $E$, $A$ or $P$ is lost out of the system, $S \rightarrow E \rightarrow P + A \rightarrow S \cdots$, and has to be replaced gradually by new $E$, $P$, $A$ or $S$.

In the analysis of the response of a photoreceptor to a flash of light which was outlined in the first part of this paper, it has been assumed that the photoreceptor was dark adapted at the beginning of the flash, and that the value of $a$ remained essentially unchanged during the first few seconds of the flash. If allowance were made for the change in the value of $a$, this would affect primarily the final equilibrium values of $w$ and $F$ rather than the initial phases of the response.

### VIII. RESPONSE TO A BRIEF INCREASE IN INTENSITY

The situation presented by a brief increase in intensity after the photoreceptor has been adapted to a given intensity level, presents a somewhat different problem than a flash of light appearing against a background of total darkness. In this case the photoreceptor is already responding at a given frequency at the onset of the flash and it is not necessary for the photoreceptor to wait for an accumulation of a threshold concentration of $E$. But it is necessary to make an allowance for the time required for $T$ to diffuse from the point at which it is produced to the point at which it produces impulses. This diffusion process introduces a lag between the increase in concentration of $E$ which is immediate and the increase in frequency of impulses which results.

Riggs and Graham[6] have investigated this type of response in the case of the Limulus and have found a lag between the end of a short flash and the maximum frequency resulting from the flash. According to the theory, the concentration of $E$ should reach its maximum at the end of the flash. The rate of production of $T$ reaches its maximum at the same moment, but the rate of arrival of $T$ at the point of production of nerve impulses does not reach its maximum till $\overline{\triangle} t$ seconds later.

### SUMMARY

An attempt has been made to trace out the implications of Jahn's modification of Hecht's theory of the photochemistry of the photoreceptor for

various characteristics of the response of a dark-adapted photoreceptor to a flash of light.

The implications of the theory have been checked against the experimental data for the Limulus photoreceptor, and the constants involved in the theory have been determined for the Limulus.

Attention has also been called to the implications for the theory of light and dark adaptation, and to the responses of a light adapted photoreceptor to brief increments of intensity.

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# TWO CASE HISTORIES OF ORTHOPTIC TRAINING TO IMPROVE VISUAL ACUITY*

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I would like to present several case histories, cases of myopia or pseudo-myopia in which orthoptic training was used. Frankly, I have handled very few of these cases and hesitate to draw conclusions as to results. I am presenting these with the idea of a good discussion period to follow, a discussion from which I know I will benefit and I hope the rest will also.

First, a word about the procedure followed. Each patient was given a series of exercises consisting of the following:

5 minutes of rotary exercises with the myoculator
10 minutes of exercises with stereoscope and special cards
10 minutes of exercises with stereoscope and Weitzenhof attachment
5 minutes of rotary exercises with the myoculator.

These exercises were given in my office several times a week, the patient using a stereoscope and cards for home training.

The cards used were designed by Dr. Julius Neumueller and consisted of 6 circles placed in three rows of two. Each circle had a pair of fine lines running vertically through the center. The distance between the centers was made variable, the bottom pair closest and the top pair the greatest distance apart with the total difference between centers of about 8 mm. Starting with card A and ending with card M the centers increased in distance of separation, the top circles on one card having the same separation as the bottom circles on the next card. Dr. Neumueller has published a paper regarding these cards and included tables so that for a given fixation distance and a given separation of the circles, the amount of accommodation and convergence in play could be determined at any time. I do not know whether or not these papers are still available but Dr. Neumueller, who is present at this meeting, can give you this information if any of you are interested.

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The Weitzenhof stereoscopic attachment is quite old so I will describe it briefly for any who may be unfamiliar with it. It consists of a rod which slides on the stereoscope bar, forming a right angle with the bar. On it are two card holders which can be made to come together or separate by turning a knob. I correlated this instrument with the special cards so that I could use the tables prepared by Dr. Neumueller.

These two patients were naval officers, the second referred by the first. The cases were taken with the understanding that it was purely experimental as I had no idea what results could be obtained. I'm not sure yet what the results are. In one case no refractive correction was given; in the other a lesser correction in minus than the indicated correction was given. Perhaps the myopia or pseudo-myopia was reduced or I may have done no more than teach the men to interpret blur circles. I hope the discussion today will help me decide what resulted.

The following are the refractive findings of the two cases.

CASE HISTORIES

Patient HG. Aet. 29. Desk work. Complains of near point visual trouble and headaches later in the day. Feels that vision is getting worse since he has been doing so much close work. Is in navy and has yearly physical coming up in next couple of months and is afraid his eyes will interfere with a promotion.

Not wearing any Rx. VA OD 20/40—
OS 20/30

Keratometer Nil.

Dynamic OD —0.50⊂—0.50 ax 75.
OS —0.50⊂—0.12 ax 105. 20/25 OU

Static and Subjective
OD —0.75⊂—0.50 ax 75. 20/20
OS —0.75⊂—0.12 ax 105. 20/20

Tentative
OD —0.75⊂—0.50 ax 75. 20/20
OS —0.75⊂—0.12 ax 105. 20/20

NRA +4.00
NRC 13/23/2
PRA —2.25
PRC 24/24/20
Phoria 1/3 4 Eso
ADD 16/13

ABD 4/2
Phoria D 2 Eso.

Diagnosis. Compound Myopic Astigmia. NRA-NRC relationship shows more plus power needed. P. Eso of 2. Low Abd. Possibility of Myopia due to over accommodation.

Treatment: Patient to wear no Rx. BI exercises at distance.

| Weitzenhof | Break | Recovery |
|---|---|---|
| 1st | 0.5 bo | 3.0 bo |
| 3rd | 6.5 bi | 5.0 bi |
| 12th and final | 15.0 bi | 11.5 bi can hold single at 10.0 bi. |

Stereoscopic cards (fused).

| | start | finish |
|---|---|---|
| 3rd | 6.0 bo | 3 bi |
| 12th | 2.0 bi | 10 bi |

VA without correction. Headaches gone. No near-point difficulty.
OD 20/20—1
OS 20/15—1

Patient FM. Aet. 25 Desk work. Only complaint is that minus lenses have been getting stronger each year. Brought in by previous patient to see if any reduction in his correction could be obtained.

Old Rx OD —2.75⌒—0.25 ax 180. 20/25
OS —2.00⌒—0.62 ax 180. 20/25
VA without Rx 20/200
20/200
K OD —0.25 ax 180 AM 43.50 D
OS —0.75 ax 180 AM 43.75 D
Refraction OD —3.25⌒—0.25 ax 180. 20/20
OS —2.25⌒—0.62 ax 180. 20/20
NRA +1.50
NRC 8/32/20
PRA —1.25
PRC 32/40/16
Phoria near 10 exo.
ADD 12/2
ABD 2/1
Phoria D 2 eso.

Diagnosis. Compound myoptic astigmia. Low PRA. Low Abd. To

try BI exercises. Patient to wear +0.50 slipovers at all times, over old correction. Gave 20/30 OU.

| Weitzenhof | Break | Recovery |
|---|---|---|
| 1st | 3.5 bi | 0.5 bi |
| 17th | 16.0 bi | 11.5 bi can hold single at 10.0 bi. |

Stereoscopic cards (fused).

| | start | finish |
|---|---|---|
| 1st | 2 bi | 4 bi |
| 17th | 8 bi | 12 bi |

Final Rx —2.25◯—0.25 ax 180. 20/20
—1.25◯—0.50 ax 180. 20/20

Visual Acuity without correction at conclusion of treatment period: OD 20/200 + OS 20/40.

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# COMMENTS ON THE LARGE UNDERGRADUATE ENROLLMENT IN CERTAIN OPTOMETRIC COLLEGES*

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In the series of articles, current in the OPTICAL JOURNAL AND REVIEW OF OPTOMETRY, depicting the role which Charles F. Prentice played in the founding of Optometry, he is mentioned as expressing the opinion that optometry would sooner or later be faced with three choices: (1) to maintain itself as an independent profession; (2) to become a form of technical service subsidiary to ophthalmology; and (3) to serve as a basis for a composite type of practitioner evolving from both ophthalmology and itself, such as does not exist at present.

It is significant that this choice, foreseen at almost the very origins of the profession, is today, several decades later, almost as applicable to the determination of the future of the profession as it was then.

Assuming almost all optometrists prefer that the profession pursue the first course—independent and recognized status among the professions—the fact that the other courses still exist does not mean that, in the intervening time, optometry has not made progress towards its goal. Legally, the field of optometry is now determined in every state, several territories, and some foreign countries. However, legality alone cannot insure either standards of performance which meet public acceptance, or scientific recognition which marks professional status. The actual measure depends upon the progress which has been made up to now in the pursuit of the other basic elements, and in the influences which may affect the nature of this progress in the future.

Two characteristics are predominant in the crystallization of all professions—so that no matter how one profession differs from another in technical background or in the segment of knowledge with which each deals, both are delineated by them and are, in fact, recognized by the public as professions because of them.

These characteristics are: an educational system providing background beyond the level of mere unspecialized education yet embracing the fundamentals of generalized education, and upon a plane equivalent

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to that of accepted systems; and a mode of conduct in practice beyond the standards applied to commercial enterprise, expressed in a fulfilled code beyond the standards of the mere legal requirements.

What has been optometry's progress in these regards since the legal steps initiating the field have been taken?

Educationally, two major changes have taken place. The time of undergraduate schooling has been gradually increased to a minimum of four years, and certain basic courses have been included or expanded. This is commendable progress, but it still leaves us with the following deficiencies:

1. Optometry maintains a percentage of proprietary schools, such as accredited professions have rather generally discarded as totally inadequate.

2. Only some of our schools are able to give or require a fundamental education comparable to the general basic courses of an accredited university.

3. The mere question of the number of years and the listing of courses and hours bears little relationship to the type of material presented; the total equipment required and utilized; the adequacy of the teaching staff; the control of educational progress towards promotion and graduation; the standards of admission and of the teaching level; the student-teacher ratio, or any of the other intimate factors upon which sound accrediting is based.

4. The mere four years alone is still only equal to the total time of either general education or of the minor professions, such as bacteriology, which are not independent of medical supervision.

5. The education received by the optometrist in some of our institutions is in part without value and recognition outside of optometry itself, with the obvious exception of that received in such of our institutions as are affiliated with universities.

Regarding the second qualification, the standard of practice, optometry has made excellent progress, and is definitely engaged in a sincere program for further improvement. The professionalization policy of the AOA, the high standards of the Academy, the various boards of examiners and the state associations have helped formulate the attitudes of both our new and old practitioners so that more and more have deserted commercial aspects, modified undesirable features in their locations, and adopted better policies affecting their practices. But even here we must look beyond the surface manifestations, and measure by the standards which are universally applicable. Much of our effort has been

expended upon alterations which, while following the correct path, are still far from reaching the ultimate. Only recently has the AOA considered a code of ethics which is comparable to that of medicine and dentistry.

If we probe even further we find still another factor which has had bearing upon the progress which we have made. Due to the war, three circumstances were directly pertinent to the readiness with which the changes towards professionalism were accepted. One, a certain number of established practitioners entered military service, including both optometrical and medical eyemen who had enjoyed extensive practices. Two, the flow of new entrants into the field was greatly curtailed. Three, the increase in exacting visual demands in a large proportion of our population not previously exposed to such demands, and the consumer advertising of suppliers, the Better Vision Institute, and various associated agencies, all brought about an increased public awareness of visual care and a subsequent increase in the demand for such care.

The combined effect of the three resulted in a volume of practice so far in excess of normal for the remaining established practitioners that no measures designed to attract patients were necessary. Since most such measures are highly commercial in flavor, many men grasped the opportunity to alter or modify their previous procedures and circumstances so as to eliminate, to some degree, the stigma of commercialism and to gain the approbation of their colleagues. Young men, entering the field, but in sparse numbers, were enabled to partake of the overflow, or step into vacancies left by enlisted predecessors, and thus bridge the normal difficult starting period without recourse to the devices which are questionable. Consequently, most of the younger men started in highly professional environments.

The shortage of practitioners, plus the increase in eye care demand, led the AOA to make a survey of its needs. Figures were published to show that optometry was greatly undermanned, that areas existed in which the number of optometrists could be doubled or tripled, that the total number was greatly below the original registration figure compiled at the dawn of the profession, and that our annual losses were exceeding our annual gains. A student procurement program was established on the basis of this reasoning.

Unfortunately, several pertinent considerations were ignored in this study. The comparison of the total number of practitioners at present with the number that registered under early exemptions and limited examinations at the time of legalization is illogical. It ignores the fact

that many men registered at that early time because of the ease with which licenses were then secured, even though the use of their licenses was haphazard. It ignores the fact that many such registrants were totally unsuited to the field. It chooses as a basis of comparison a set of arbitrary figures based upon no determined needs, increase or decrease of function or available demand.

The worry about the decrease of new applicants during the war, while more appropriate, was still an exaggeration in that the surplus which is following could readily have been forecast from the experiences following World War I.

Finally, the survey of practitioners to population is essentially an example of statistical exercise. The total average is estimated without weighting for the various regional discrepancies. The region with the highest ratio of population to optometrists is found to be that which, in every national survey, ranks lowest in industrialization, lowest in average income, and highest in illiteracy—the most obviously negative qualities for success in the practice of visual care. Yet, the total averages of the country are computed with this region included without modification.

The number of medical eye practitioners is ignored in the survey. Yet many laboratories have assured the writer that certain medical eye practitioners enjoy a large refractive practice.

In conclusion, the total number of people bears no consistent relationship to the degree of demand for visual attention. The survey established an arbitrary figure of one optometrist for every four thousand people. If this had been stated to read one optometrist for every four thousand patients, no quarrel would exist, but when the ratio is based upon the total population, including babes in arms and senile paralytics, illiterates and the blind, people on relief and fathers of eight earning $1500 a year, then a question can well be raised.

In a certain district of some 50,000 population, seven optometric offices exist. This would provide a rough ratio of 7000/1, a figure which should insure room for nearly twice the number according to the AOA estimate. However, there are also five medical eye practitioners, making a total of twelve and reducing the figure to about 4000/1. This is then a theoretically perfect situation according to the estimates, particularly since the district is highly industrialized and has a prosperous agrarian drawing area. But a survey of the practices in the district, which range in duration from a few months to over forty years, reveals that only

one of the twelve is fully occupied throughout his normal working day in caring for vision, two others are fully occupied by partaking of ear, nose and throat work in addition, and the remainder have definite and varying periods throughout the day, even at this prosperous time, in which their services find no demand. While one illustration cannot prove the point, the manner in which the figures are so overwhelmingly refuted is remarkable.

It is true that during the war a great number of optometric practitioners were unable to care for the volume of patients requiring their attention. However, times have changed. Some factory workers, particularly women, have already relinquished their jobs, the balance no longer are working overtime to the extent of producing exhaustion; the take-home pay of the average worker, while in total, higher than pre-war, is individually lower than it has been; fundamental living costs have risen and many practitioners, both optometric and medical, have returned from military duty. To offset this, the public awareness of visual attention has been increased, but to balance this, we find that the profession faces an influx of new practitioners in the next few years such as will equal the normal rate of the entire pre-war decade. And in this lies the most serious influence upon optometry's future.

It has been gratifying to note that the recent initiates into practice have entered into personal private practices of good ethical quality. This speaks well for optometry's future, and we may feel grateful for the efforts which have been made to acquaint and instruct our practitioners in the demeanors of the professional man. But ethics instruction alone will have no lasting effect unless the factors determining the economics which influence ethics are favorable.

In a period of increased demand for eye care plus a reduced supply, the neophyte found that a practice more or less awaited him, and that the typical waiting period was sharply mitigated. Ethical forms of practice to the beginner who must hoard his pennies are far more economical than commercial practice, with its larger outlays in rent, fixtures and advertising. Under such circumstances, no great moral combat was necessary to influence the beginner to follow the course which his own inclination and the desire of the profession found more agreeable.

It is true that the beginning physician has followed this course even under the most adverse economic circumstances. It would appear that if the young optometrist could be made as aware of the prerequisites of professionalism as the young physician appears to be, the influence of economic circumstances upon his behavior should be lessened. But it

must be realized that the young physician faces an entirely different set of circumstances than does the young optometrist.

The physician who begins a practice finds it to his greatest economic advantage to adhere rigidly to the professional code. If he is a general practitioner, his early practice originates in the night and emergency calls which older practitioners refer to him. If he is a specialist, he is even more dependent upon the respect of his fellow practitioners. In either case, medicine has developed to the fortunate position in which the young man can only secure the respect and cooperation of these older colleagues by adhering to the strict professional code. To flaunt that code is definitely an unwise economic procedure. In addition, the respect of the nursing and pharmaceutical professions, and even admission to hospital facilities, to further study, and to society activities, with its insurance and other features—all requisite to the development of a practice—are dependent upon this same adherence. Even if no individual indoctrination existed, the standards of the medical profession as a whole make it economically essential that the beginning physician conduct himself along strictly ethical lines.

But unfortunately, in the present status of optometry these same advantages do not apply. From the purely economic standpoint, it cannot be denied that a practice can be more quickly established under commercial conditions than under professional ones. The beginning optometrist cannot customarily look for referrals from the older men; except in individual cases, he cannot look for referrals from the general medical practitioner, or from the field of nursing, nor can he expect to do so until that time comes when optometry has earned and is accorded the recognition it requires by these other professions; he is not customarily curtailed from his society's advantages because of misbehavior. The more ethical he is, the longer it will actually take him to fully establish himself in practice. Adherence to the ethical standards requires a moral stamina, a devotion to ideals and a desire to abet the profession at considerable personal sacrifice. To enable the starting optometrist to enjoy the economic advantages which the young physician receives as an adjunct of an ethical attitude, and to make the professional path not only the more advantageous from an ethical view but also from an economical one, requires:

(1) That our various societies shall deny their advantages to the non-conformist.

(2) That our established practitioners shall continue to move towards wholly professional environments, so that the beginner shall

not face the competitive aspects of commercial practices.

(3) That the profession shall achieve recognition sufficient to enable the young optometrist to enjoy the advantages of referral which the young medical specialist enjoys.

(4) That a surplus of demand for visual care beyond supply be maintained to the extent that the older established men can aid the beginner by referral of the overflow.

Should we once fully gain these objectives, the problem of professionalization in optometry will cease to exist. The nature of practice will be almost as automatic as it is in the medical profession, the economic advantages will lie with ethical practice, and optometry will not only have secured the recognition due it, but indemnified its place as an independent and recognized profession.

The first two steps can be obtained by a process of education and indoctrination of the men in practice, plus a realization on their parts of the increased advantages accruing from professional attitudes, to the profession and hence to themselves. The elimination of the purely commercial elements, such as corporate interests, is not wholly possible by this means, it is true, but it is possible by means of legislation and by making private practice sufficiently desirable so that such interests find few optometrists available to conduct their enterprises for them.

The third premise, that of securing the recognition due us is not an easy one. To encompass it, we must first be sure that we are in a position to justly warrant it by eliminating our weaknesses and securing our positions. As has been said so frequently before, we cannot merit recognition until we have both wings of our house in order; a proper educational structure, and a proper professional attitude.

Since we have not yet achieved any of the first three premises in full measure, we have only the last to assist the beginning practitioner in starting his practice in a professional manner, and to insure the established practitioner of no economic loss in modifying his accustomed procedures. We must maintain a strict control of not only the type of practitioner we admit to the field, but also of the numbers of new practitioners which we admit.

As soon as overcrowding arises, the flagrant elements of commercialism will again attempt to dominate, the established practitioner is wary of change, and the new practitioner, no matter how indoctrinated, finds it quite difficult to fulfill his idealistic concepts. Even medicine, with all its tradition and its advantages, saw the rise of commercialized and corporate practices during the last depression.

Therefore, since we cannot as yet assure the neophyte of those aids to practice which his medical parallel enjoys, we must be very careful about undermining the only economic aid which we can give him—a consistent demand for his services.

It must be remembered that medicine has, directly or otherwise, maintained a rather consistent quota system of students in its schools and graduates into its practice.

It is significant that at this very moment we seem to be unaware or impotent to the very situation which might topple our objectives. We are gratified that so large a number of students appear to prefer the study of optometry. But we seem blind to the fact that an alarming number of these candidates have actually been admitted into some of our schools of optometry.

It has spoken well for medicine that for many years it has had a far larger request for admission to its schools than it was desirous of admitting. This demand has provided it with the opportunity of gleaning from its applicants the men of superlative ability, so that medical students as a group represent the upper scholastic strata, able to take not only a leading part in the pursuit of the profession but in all the affairs of society, and thereby furthering the status of the profession from one generation to the next. Some of our optometric schools are following the same commendable course. With facilities for only a given number, these institutions have refused to lower the standard of instruction, and have restricted themselves only to the number they can handle by selection of the men of highest caliber.

But other schools of optometry have accepted great numbers of students and have attempted to expand already meager facilities to garner more. Apparently, these institutions are interested more in large student enrollment than in that of the profession, but how can the profession itself ignore the consequences of this act and not foresee the results of a large group of indiscriminantly selected, disillusioned graduates sent forth at one time to the various state boards?

Undoubtedly, when the state boards are faced with these unprecedented numbers, some attempt will be made to restrict the entrants into a given state. However, once having graduated, most of the candidates will be bound to secure a license, either by repetition of the board examination or by an attempt in an adjacent state. When whatever existing patient excess is exhausted; when sheer necessity has spurred these men to whatever competitive devices they can utilize; when those that fail accept the proffers of the corporate interests, what will happen

then to optometry and its efforts for full professional stature?

Is it less cruel to admit a veteran to school and exhaust his funds and time and to present him to a state board which either cannot pass him, or if it does, enables him to face a situation far from his dream of professional, useful and independent service, than it is to halt him before he enrolls, before he expends his subsistence and while he yet has the time and means of entering some other vocation?

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# ANNUAL REPORT OF ACADEMY SECRETARY

## INTRODUCTION

As an academy we are now concluding our 25th year of participation in optometric affairs. This quarter century has added much to optometric growth and stature, and during this period, the Academy through its loyal membership has played an important role in the development of visual science.

The year 1946 marks another milestone for both optometry and the Academy. It saw the start of a nationwide reconstruction program and the end of government controls. It brought into being an accelerated demand for free enterprise which will, at least for the time being,

retard those who were so insistent for the regulation of business and health services.

It was a year, too, in which the Academy made further progress in its contributions to refractive science through

(1) The educational meetings of the Academy and its chapters wherein technical papers were presented and discussed.
(2) Grants-in-aid of Academy funds to assist specific research studies.
(3) Technical material published on matters relating to visual science, and
(4) Continued Academy leadership in setting the general pattern and tone of optometric practice.

LOCAL CHAPTERS

The start of 1946 found the Academy functioning with ten active local chapters. These are the Cuyahoga, Indiana, Iowa, Maryland, Michigan, Minnesota, New Jersey, New York, Southern California and Vermont chapters.

These chapters exert local influence upon all optometrists and bring close to home the professional ideals which constitute an important portion of the general program of the Academy. Plans are now under way to establish additional local chapters, and in fact, the Illinois group will probably receive their charter as a local chapter at the Philadelphia meeting. Several other groups are in the process of initial organization, and are expected to file their applications early in 1947.

The Academy will continue its program of refunding to each active local chapter $2.00 for each practicing optometrist member of the local, who is also a Fellow of the Academy, the funds so refunded to be used for extension purposes of the local chapter.

MEMBERSHIP

Upon appropriate action, 44 optometrists, scientists and educators have been awarded Fellowship in the Academy by the Executive Council during 1946. These men were brought into the Academy upon recommendation of members. Our local chapters have proven themselves invaluable in screening applicants and assisting the officers and examining board of the Academy. We welcome these new members and are confident that their associations in this organization will prove stimulating and mutually helpful.

ACADEMY LOSSES BY DEATH

I regret to announce that during the year we lost two members of

the Academy by death. These men had been active in the Academy since its earliest days and each had made a very substantial contribution to the science of visual care. At this time the Academy pays tribute to Dr. G. O. Ohlsson of Detroit, Michigan, and to Dr. Max Poser of Rochester, New York.

RESIGNATIONS AND SUSPENSIONS

During 1946, two members of the Academy resigned and during the same period, three members were dropped for failure to pay their dues. As Secretary, I also regret to announce that three members were suspended for infractions of rules relating to their practices in optometry.

In this regard, it is fitting to observe at this time that rules of professional conduct must be observed at all times by members of the Academy and that no deviation from these will be permitted by the Executive Council.

PROGRAM AND PAPERS COMMITTEE

Under the direction of Dr. D. G. Hummel and with the assistance of his several committees, the program which has been arranged for our Philadelphia meeting is again one which typifies the interests and outlook of those who comprise the Academy membership. The general excellence of the papers to be presented at the 1946 annual meeting of the Academy is indicative of the high purpose and fine work done by the Program and Papers Committee.

RESEARCH PROJECTS COMMITTEE

The Research Projects Committee under the chairmanship of Dr. Robert E. Bannon has screened and reviewed several visual studies which seemed worthy of Academy grants-in-aid.

Two of these were selected with the approval of the Executive Council. These were (1) a grant-in-aid to the Dartmouth Eye Institute, Hanover, New Hampshire, in the amount of $1,000.00 for a study having to do with refractive findings made both with and without a cycloplegic. This study will be supervised by Dr. Robert E. Bannon. (2) A grant-in-aid to the Ohio State University, School of Optometry, Columbus, Ohio, in the amount of $1,000.00 for a study having to do with color vision. This study will be supervised by Dr. Glenn A. Fry.

Additional funds for use as Academy grants-in-aid will be available during 1947 and those wishing to apply should send an outline of their proposed research study to the office of the Academy, where it will be given consideration by the committee.

ROSTER

Again during 1946, an Academy roster was published. This booklet of 48 pages contained both an alphabetical and a geographical roster of Academy Fellows.

In addition, it included the constitution and by-laws of the Academy. A new 1947 edition will be distributed to all members shortly after the first of the year.

SPATIAL SENSES AND MOVEMENTS OF THE EYE

The English translation of Edward Hering's "Spatial Senses and Movements of the Eye" by Dr. Carl A. Radde continues to sell in small quantities and wherever received is acclaimed as an outstanding contribution to English texts on binocular vision.

THE FINANCIAL POSITION OF THE ACADEMY

On January 1, 1946, the Academy had cash on hand in the amount of $3,053.91. This total including $2,676.05 on deposit in the Academy account in the Northwestern National Bank of Minneapolis and $377.86 in the Academy account in the Bay Street Branch of the Bank of Montreal at Toronto. In addition, it had accounts receivable in the form of 1946 dues from its members of approximately $4,600.00.

Against these reserves were $248.55 of unpaid 1945 Academy bills, these being in great part the result of our December, 1945, annual meeting, and an anticipated 1946 annual budget, which under an extended Academy program as approved by the Executive Council, amounted to a total of $5,959.50 for the 12 calendar months of 1946. This annual budget included the costs of running the Academy during 1946, the costs of the 1946 annual meeting and also included a $2,000.00 annual appropriation by the Academy for visual research work.

On December 1, 1946, the fiscal position of the Academy was as follows:

Cash on hand in the amount of $3,649.68. This total includes $3,178.05 on deposit in the Academy account in the Northwestern National Bank of Minneapolis and $471.63 in the Academy account in the Bay Street Branch of the Bank of Montreal at Toronto. In addition, the Academy had accounts receivable of $185.00.

Against these current reserves were the remaining unexpended appropriations as set up in the 1946 annual budget in the amount of $2,160.50. As the majority of these annual Academy operating costs fall due in December, these funds will be in great part expended during

this month in accordance with prior approved budget plannings. Following the payments of these Academy accounts it is now anticipated that the Academy will have an unencumbered balance on hand as of December 31, 1946, of $1,489.18. It should also be borne in mind that with our present membership we will start the year 1947 with a dues account receivable of approximately $5,300.00.

THE EXECUTIVE COUNCIL

I wish again as Secretary to express my sincere thanks to each member of the Executive Council for the inspiration and assistance which he has rendered the Academy throughout the year. The business of the Academy is largely transacted by the Executive Council and these members have acted in behalf of this organization throughout 1946, giving their close attention to the many matters presented to them which had to do with the well being of this organization. The council has carried its responsibilities well and members of the Academy join with me in extending sincere appreciation to these officers.

PRESIDENT DR. J. FRED ANDREAE

As Secretary of the Academy, it is my privilege to again express on behalf of all members our deep appreciation of the valued service rendered the Academy by Dr. J. Fred Andreae, who is now concluding his second year as president of the Academy. During this period, Dr. Andreae has never shirked the responsibilities of his office and has stood ever willing to give the Academy the full measure of administrative skill expected of him.

As a past secretary of the Academy and more recently as president, he has left his indelible mark of leadership upon the organization, and during the years has brought the Academy to a full fruition of excellent performance.

As our chief executive, Dr. Andreae has given this technical society directorship of high order and it is with sincere gratitude that we again tender to him our thanks for his valued services.

CONCLUSION

Although America has made much progress in its reconversion program, a great deal of work remains to be done.

Optometrists as members of the great group doing health work in this country can play their part in the reconversion period ahead by continuing to maintain the high level of public service which has historically characterized their work.

The Academy, too, has its place in this general scheme of health

benefits and will continue to give leadership in the development of the technical and professional aspects of proper visual care.

It is the writer's privilege to report that the Academy is well equipped to do its job in the year to come.

CAREL C. KOCH

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## ABSTRACTS

A department in which will appear abstracts of the literature of optometry, ophthalmology and applied optics. These will be classified according to the following list although contributions to all sections will not necessarily appear in each issue.

1. Ocular Refraction.
2. Physiological Optics and Color Vision.
3. Ocular Muscles.
4. Orthoptics and Reading.
5. Anatomy, Histology and Embryology.
6. Ocular and General Pathology.
7. Ophthalmic Lenses and Material.
8. Instruments.
9. Hygiene and Illumination.
10. Applied and Physical Optics.
11. Education, Sociology and Economics.
12. Miscellaneous.

### 4. ORTHOPTICS AND READING

ORTHOPTICS. Eric Bateman. Transactions of the Middle East Optical Practitioners Group. Cairo, Egypt. Vol. 1. 1945.

The subject matter of the paper was a general survey of the underlying philosophy of the science together with the history of its development. The lecturer made it plain that orthoptics is not simply a matter of treating strabismus, although this is an important part of the subject.

Emphasis was laid on the fact that orthoptics cannot be regarded as entirely independent of refraction and the related functions of accommodation and convergence, as the problem concerns mal-functioning of the binocular apparatus as a whole. Moreover, each step in treatment is linked with a corresponding psychological state.

The speaker outlined the manner in which the science had developed since Worth introduced to England his original technique for treating strabismus.

Considerable success attended the early efforts of orthoptists, working with the Worth technique, but the translation of Cantonnet's work and the adoption of his ideas gave orthoptics a new impetus. While Worth attempted to cure at the "high level" of an already existing fusion sense, the new teachings took us back in time to the point at which the mal-adjustment occurred, and re-education progressed from that point forward. Developing a technique which combined the teachings of Worth and Cantonnet, workers at the London Refraction Hospital

found that cures which had been taking 12-18 months, now were achieved in 3 to 6 months.

Touching on the psychological aspect of the problem the lecturer advanced the view that "essentially alternating squint" is in fact the results of a true neurosis, the individual with this defect being unable to face reality and so retires to an introspective state. Fusion is *repressed* at the same deep level as the situation which cannot be faced. With the release of the neurosis fusion could be developed.

T. O. B.

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6. OCULAR AND GENERAL PATHOLOGY

CATARACT. K. D. Foggitt. Transactions of the Middle East Optical Practitioners Group. Cairy, Egypt. Vol. 2. 1946.

Before discussing the different types of cataract, the lecturer described the histology of the crystalline lens and gave a brief account of the embryonic development of the eye.

Foggitt classified cataracts into five main groups: (1) senile types; (2) infantile and adolescent; (3) traumatic; (4) complicated; (5) metabolic and endocrinal.

The cause of senile cataract may be lack of oxygen reaching the lens, as for example in glaucoma where there is interference with the vascular supply of the eye; or vitamin deficiency—probably lack of vitamin B, the lens is believed to manufacture its own vitamin C; or due to toxins.

Different types of senile cataract are many, but a few of the main types were described. The commonest is the cuneiform type, where the opacification is wedge-shaped. In peri-nuclear punctate cataract, opaque dots form between the lens fibres. In cupuliform cataract an opacity forms on the back of the lens, and this is usually followed by nuclear opacification. An opacity on the back of the lens causes greater interference to central vision than when elsewhere. In nuclear cataract the central area of the lens becomes myopic while the peripheral sectors are probably hyperopic. This can be investigated best using a plane mirror and a small source of light. A nuclear cataract usually progresses slowly into a "black" cataract.

Among the infantile and adolescent types of cataract commonly met are blue dot cataract, generally accepted as non-progressive, and coronary cataract. Lamellar cataract is common, and this may be due to faulty action of the parathyroid gland.

Traumatic cataracts are common, e.g., (a) from contusion of the

eye causing rupture of the lens capsule; (b) by perforation of the lens, as by a thorn; (c) from foreign bodies entering the lens; (d) after cataract operations or from accidental damage during other eye surgery; (e) from excessive heat, lighting, and possibly from other forms of radiant energy.

A complicated cataract is a condition where there is some other pathology of the eye present apart from the cataract itself. Such complications might be glaucoma, chronic uveitis, retinal detachments, neoplasms, foreign bodies, etc. The importance of diagnosing a complicated cataract is that in these cases the patient is a much worse operation risk.

Metabolic type cataracts include those caused by diabetes, tetany, or any other systemic condition which interferes with metabolism. Cataract is found associated with many of the endocrine diseases such as cretinism, Mongolian idiocy, etc., and also in certain skin diseases.

The lecturer stressed the advantage of the ophthalmic surgeon seeing a case before the maturity of the cataract prevents a clear view of the fundus. This gives an opportunity for assessment of the post-operative prognosis.

T. O. B.

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# VOLUME 23, 1946, GENERAL INDEX

This is an index covering all of the departments of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY. The letters used to explain in which department the material indexed appears are as follows: (OP), Original paper; (E), Editorial; (T), Transactions of the Academy; (PI), Procedure and Instrumentation by R. H. Ehrenberg; (SR), Special Reports; (C), Correspondence; (Ab), Abstracts; (I), Inquiry and Explanatory Notes; (BN), Book Notices; and (A), Announcements.

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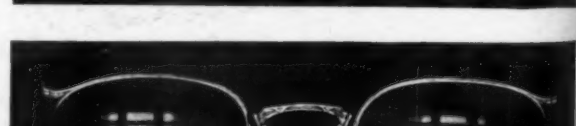

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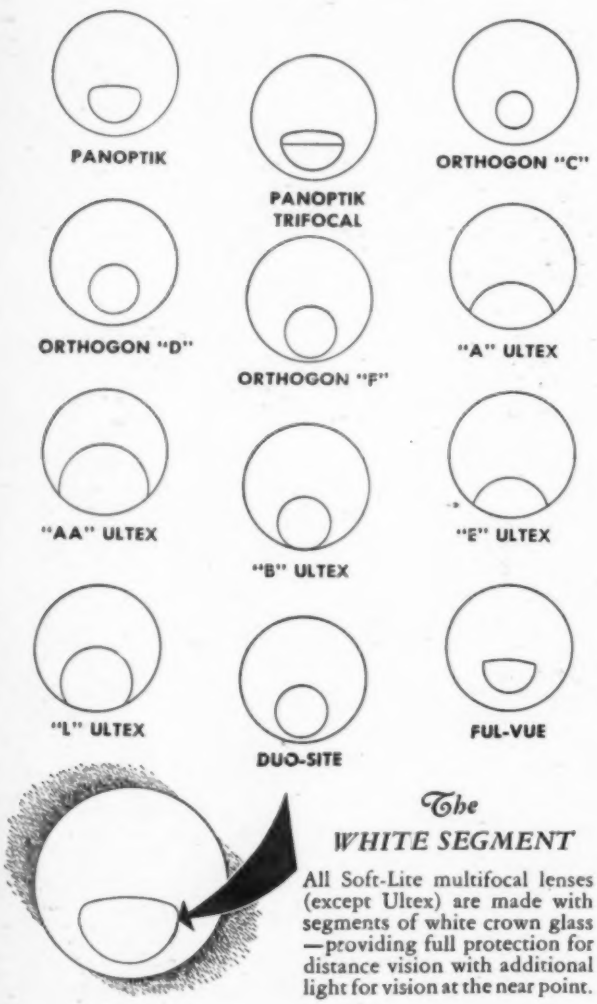




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*Eyes Well Cared for*
*Eyes Well Dressed*

A Cushion-Lock Numont Rimless Ful-Vue Forms the Setting for Kurova Wide Angle Lenses.

**. . . The Lenses are Cushioned Against Breakage**

ARMY E NAVY

*tinental* INDIANAPOLIS

# FLUORESCENT LIGHTING and the 4th COMPONENT

Many patients complain of eye discomfort after the installation of fluorescent lighting in the office, home, or factory. Some authorities say this trouble is due to overbrightness and glare from faulty installations. Others claim the cause can be traced to uneven spectral quality of fluorescent light. And the presence of stroboscopic effect has also been pointed to as a possible source of visual distress.

Whatever the reason for these complaints, case histories attest to the comfort provided by Soft-Lite Lenses under fluorescent light. Professional experience proves that the 4th prescription component, *neutral light absorption*, is particularly beneficial in prescribing for cases in which discomfort is caused by fluorescent lighting. When the practitioner considers the 4th component, Soft-Lite Lenses are most frequently prescribed . . . because they protect the eyes and maintain natural, neutral light transmission. Available in single vision and most popular multifocal forms.

*Soft-Lite Lenses*

**provide neutral absorption—the 4th prescription component**

**THE FOUR PRESCRIPTION COMPONENTS**

| | |
|---|---|
| SPHERES | PRISMS |
| CYLINDERS | LIGHT ABSORPTION |

The SENSATION of 1940

# Shurset

RIMWAY FUL-VUE

. . . with top arms SET in place by an ingenious plastic-cushioned method

This ad appeared in the **Optometric Weekly** issue of MARCH 15, 1940

*Shurset* is the new Shuron Rimway Ful-Vue construction which eliminates *all* strain on lenses imposed by handling of temples. A semi-strap holds the top bar firmly to the lens . . . sets it *surely*, without "play" or wobble.

In this construction, the metal mounting carries all handling strain —*the lenses do not support anything but themselves!*

This semi-strap construction eliminates the adjusting of strap shoes and ears to conform to the lens—no straps to slip, ply and spoil.

*Shurset* is styled in three popular Shuron bridge designs—Rosvall, Ronvinne and Ronbar—for either feminine or he-man wear. It can take it!

TOP VIEW

SIDE VIEW

## *Stocks Now Available!*

Complete stocks of *Shurset* Rimway Ful-Vue mountings are now available for your prescription use. Ask your independent wholesaler's representative to show you his new *Shurset* sample case—it really shows what you can do with this unique mounting.

SOME *Shurset* FEATURES

1. Combines frame strength with the inconspicuous appearance of rimless.
2. Shock-proof mounting of "semi-strap" with plastic-cushioned screws.
3. Lens thickness no obstacle.
4. Screws stay tight—no wobbly straps.
5. No loss of D. B. L.
6. Three popular styles: Ronvinne, Rosvall and Ronbar.

Shuron OPTICAL YEWEAR Geneva, N. Y.

*is the*

# LEADER

*in*

# 1946!

EYEWEAR OF DISTINCTION *by* Shuron

2-Phys
PHYSICS READING ROOM

VOL. 23, No. 4 APRIL, 1946

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ARMY E NAVY

*Continental* INDIANAPOLIS

# The 4th Component and Glare Tolerance

When eyes are intolerant to glare, the correction furnished by white crown lenses may not be sufficient to bring comfort. Since the experience of refractionists has shown that extra protection is often needed, the 4th component, *neutral light absorption*, becomes a basic part of the ophthalmic prescription.

For maximum visual acuity and comfort, the practitioner considers all four prescription components, and when neutral light absorption is indicated, chooses Soft-Lite Lenses—for natural light transmission, wide variety of lens forms, and flawless craftsmanship.

Available in first quality single vision and a wide range of multifocal forms—five accurately graded degrees of absorption.

*Soft-Lite Lenses*

**provide neutral light absorption—**
**the 4th prescription component**

**THE FOUR PRESCRIPTION COMPONENTS**

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# For on the Job Protection . . .

## THE RELIANT SAFETY GOGGLE

### Practical and Inexpensive • Saves Wear on More Costly Glasses

An industrial frame you can furnish patients as an extra pair of glasses. The Reliant is made of non-tarnishable, non-corrosive Villadium metal. It is welded for strength and has a sturdy reinforced double bar bridge. Also, equipped with plano safety lenses, the Reliant is excellent for visual job hazard protection for non-spectacle wearing workers.

*Continental* · INDIANAPOLIS

# The 4th Component and Color Values

The even color transmission of Soft-Lite Lenses makes possible both the precise color evaluation necessary to the professional artist and the natural comfort desired by the layman. In addition, Soft-Lite allows the refractionist to prescribe for his patient neutral absorptive lenses that are not habit-forming. Light intensity is reduced, color values unchanged.

When the patient's eyes are sensitive to glare and overbrilliance, the refractionist considers the 4th prescription component, light absorption. He knows that Soft-Lite is synonymous with *neutral* absorption. That is one reason why Soft-Lite Lenses, in their complete range of single vision and multi-focal forms are the most widely prescribed absorptive lenses in the world.

*Soft-Lite Lenses*

**provide neutral light absorption—**
**the 4th prescription component**

**THE FOUR PRESCRIPTION COMPONENTS**

| | |
|---|---|
| SPHERES | PRISMS |
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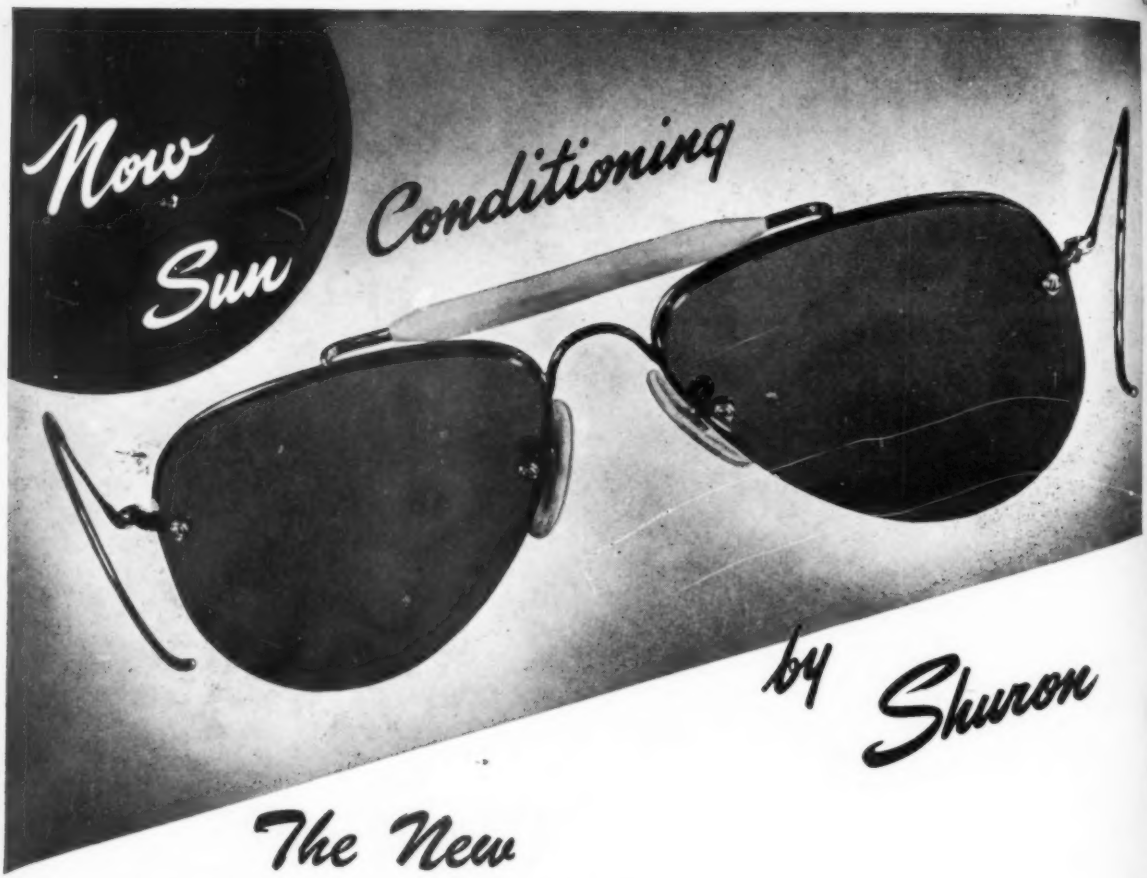


*The New*

# SHURSET SUNREX *is the first of a series of scientifically corrected Sun Glasses that condition the sun according to Professional Rx Standards.*

**SUNREX features are**

1. Tried and proven Shurset construction.
2. Much lighter in weight than the average sun glass.
3. King size and Queen size for men and women.
4. No. 3 Shade Green Sunrex lenses.
5. Eliminates harmful ultra-violet and infra-red radiation.
6. Sunrex blanks available for Rx use.
7. Distributed to the Profession by Independent Supply Houses.

**SUNREX *will help complete the* OPTICAL WARDROBE**

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VOL. 23, No. 6 JUNE, 1946

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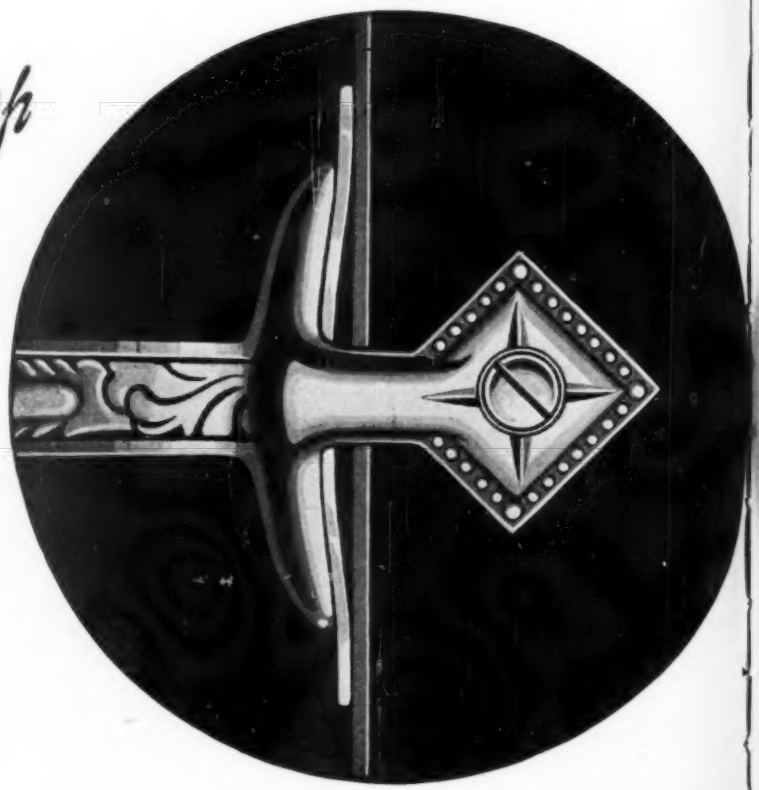
## *Spring Strap is Back*



WE COULDN'T make everything during the war. *Protexit* Spring Strap rimless mountings were one of the items sacrificed to make way for production of defense materials. Now comes good news—*Protexit* is back. Those of you who like the spring strap construction and its lens protection advantages can again get *Protexit* Spring Strap rimless.

*Protexit* is Continental's trademarked name and *Protexit* mountings have behind them Continental's guarantee of craftsmanship and high gold content.

As before, *Protexit* springs are carefully tempered to give just the proper pressure against the lens and are fastened firmly and permanently to the straps.

Two *Protexit* styles are available now—the Rio and the Hibrow Numont. Order from your independent wholesale laboratory and order by the name *Protexit*.

*Continental* INDIANAPOLIS

# The 4th Component and Reflected Light

**V**isual discomfort is often caused by the glare and excessive light of present-day conditions which is reflected to the eye from *surfaces below eye level.* The natural light shielding mechanism of the eye is not adequate, frequently, to provide the necessary protection—so many practitioners bring additional protection to light-sensitive eyes by prescribing Soft-Lite Lenses. Thus, they introduce into the prescription the 4th component, *neutral light absorption.* Generally helpful in all cases where photophobia exists, there is a Soft-Lite lens form and degree of absorption for each prescription requirement.

*Soft-Lite Lenses*

*provide neutral light absorption—*
*the 4th prescription component*

| THE FOUR PRESCRIPTION COMPONENTS | | |
|---|---|---|
| | SPHERES | CYLINDERS |
| | PRISMS | LIGHT ABSORPTION |

"WHAT ABOUT MY

# Optical Wardrobe"

**Your patients will be asking this question after seeing our national advertising**

IN

**LIFE**

(issue of May 6, 1946)

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Going Places
THE CANTERBURY CUSHION-LOCK NUMONT
★ A Ful-Vue Rimless 1/10 12K Gold
Filled Cushioned Against Breakage
Continental INDIANAPOLIS

# How The 4th Component Brings Patient Satisfaction

OFTEN perplexing is the problem of the dissatisfied patient whose refractive correction has been verified and proved to be accurate. In many cases, the 4th prescription component, *neutral light absorption* provides the key to the problem. It has been found, as countless case histories indicate, that spherical, cylindrical, and prismatic corrections are sometimes not sufficient to bring patient comfort. Neutral light absorption, by protecting eyes from glare and overbrilliance, brings greater patient comfort, and therefore, maximum patient satisfaction.

To introduce the 4th component into your patient's prescription, prescribe Soft-Lite Lenses. There is a Soft-Lite lens form and degree of absorption for each prescription requirement.

*Soft-Lite Lenses*

**provide neutral light absorption—**
**the 4th prescription component**

**THE FOUR PRESCRIPTION COMPONENTS**

| | |
|---|---|
| SPHERES | PRISMS |
| CYLINDERS | LIGHT ABSORPTION |

# YOUR PATIENTS ARE

# *Beauty Conscious*

It is true that they look to you for corrected vision but they are apt to take your painstaking diagnosis and prescription for granted.

If you prescribe glasses which meet your patients' standards of fashion and beauty, they will wear your prescription with pride and pleasure.

It is our purpose, through the Optical Wardrobe idea, to enable you to style your patients' faces with eyewear that is correct for every costume and occasion.

*Shuron*

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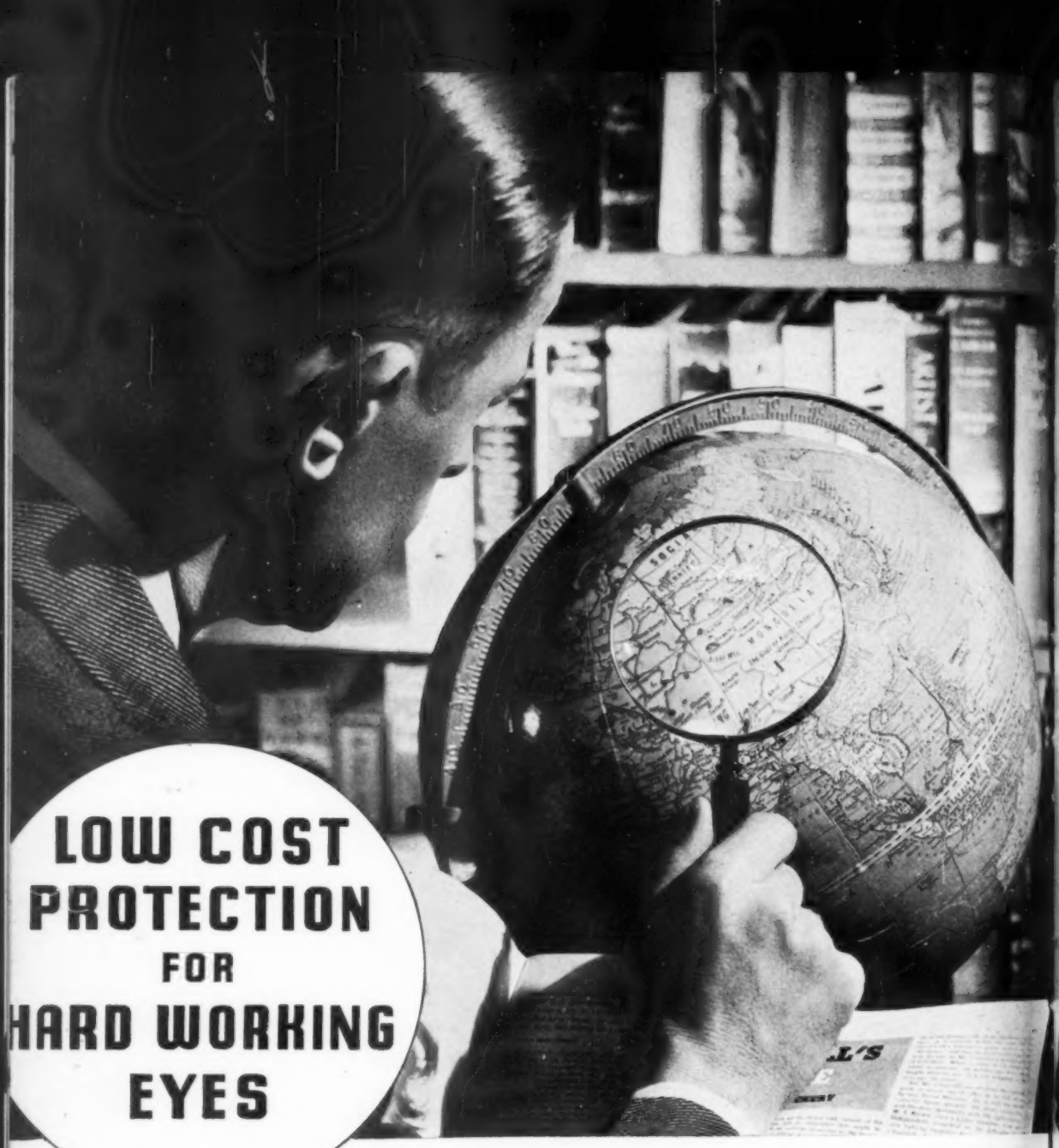

# LOW COST PROTECTION FOR HARD WORKING EYES

WHERE fine line facts or figures make up the daily diet of the eyes, a little help is often in order. Shown below are four optically ground and polished hand magnifiers, with a size choice to suit the purpose. Recommend them where you find the need. They are inexpensive. They will do much to relieve visual stress and strain.

| | |
|---|---|
| No. 622 . . . . . | 2½" Round |
| No. 623 . . . . . | 3¼" Round |
| No. 624 . . . . . | 4" Round |
| No. 625 . . . . . | Rectangular Toric |

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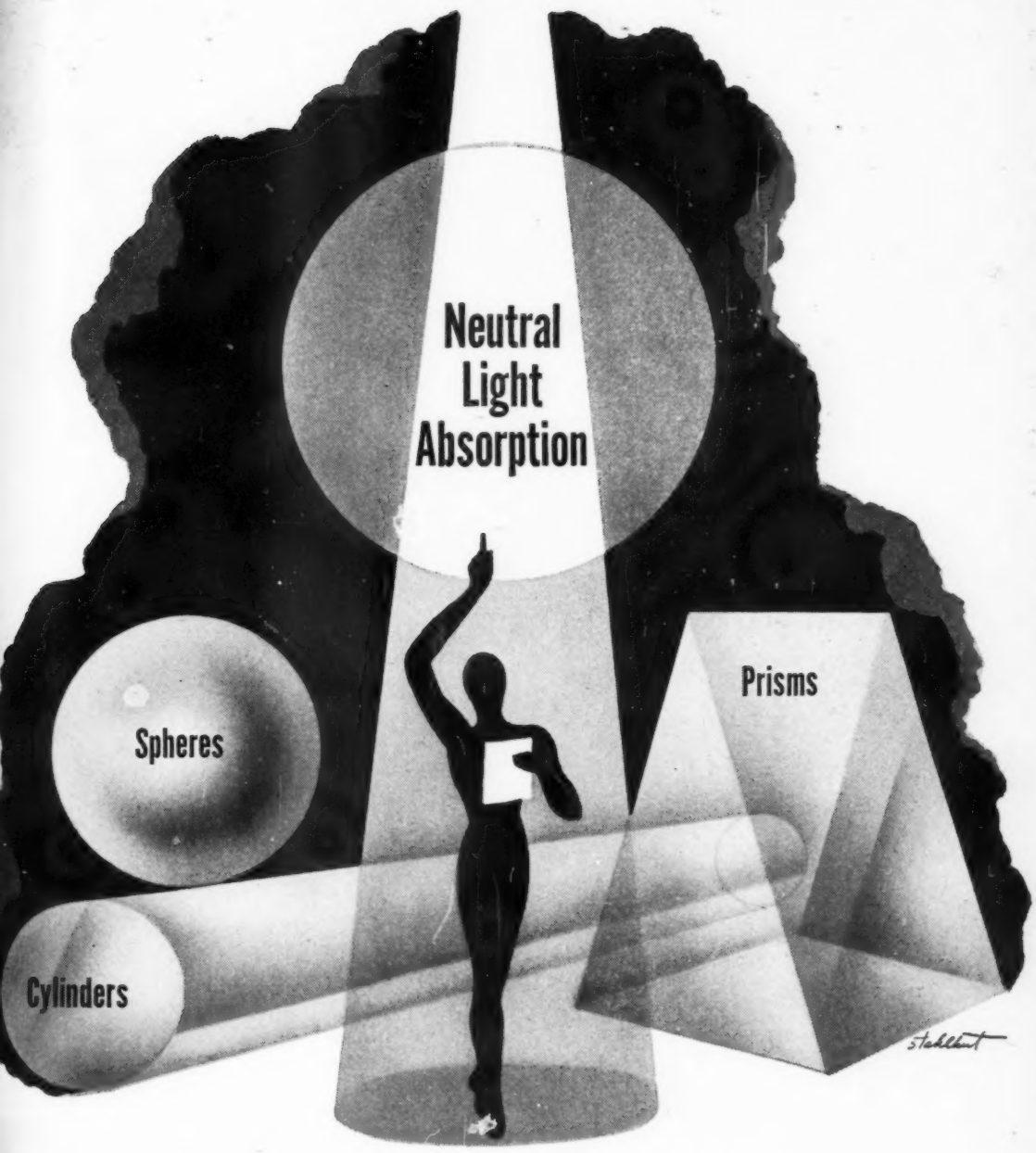


# MEANS TO AN END

The four prescription components are means to an end. They help the practitioner bring visual comfort and visual efficiency to his patient. Soft-Lite Lenses provide neutral light absorption, the 4th prescription component. Used either alone, or in combination with the other three components, neutral light absorption is a valuable aid in bringing comfort and satisfaction to light-sensitive eyes.

*Soft-Lite Lenses*

Glamorous - Piquant
FIESTA
by
Shuron

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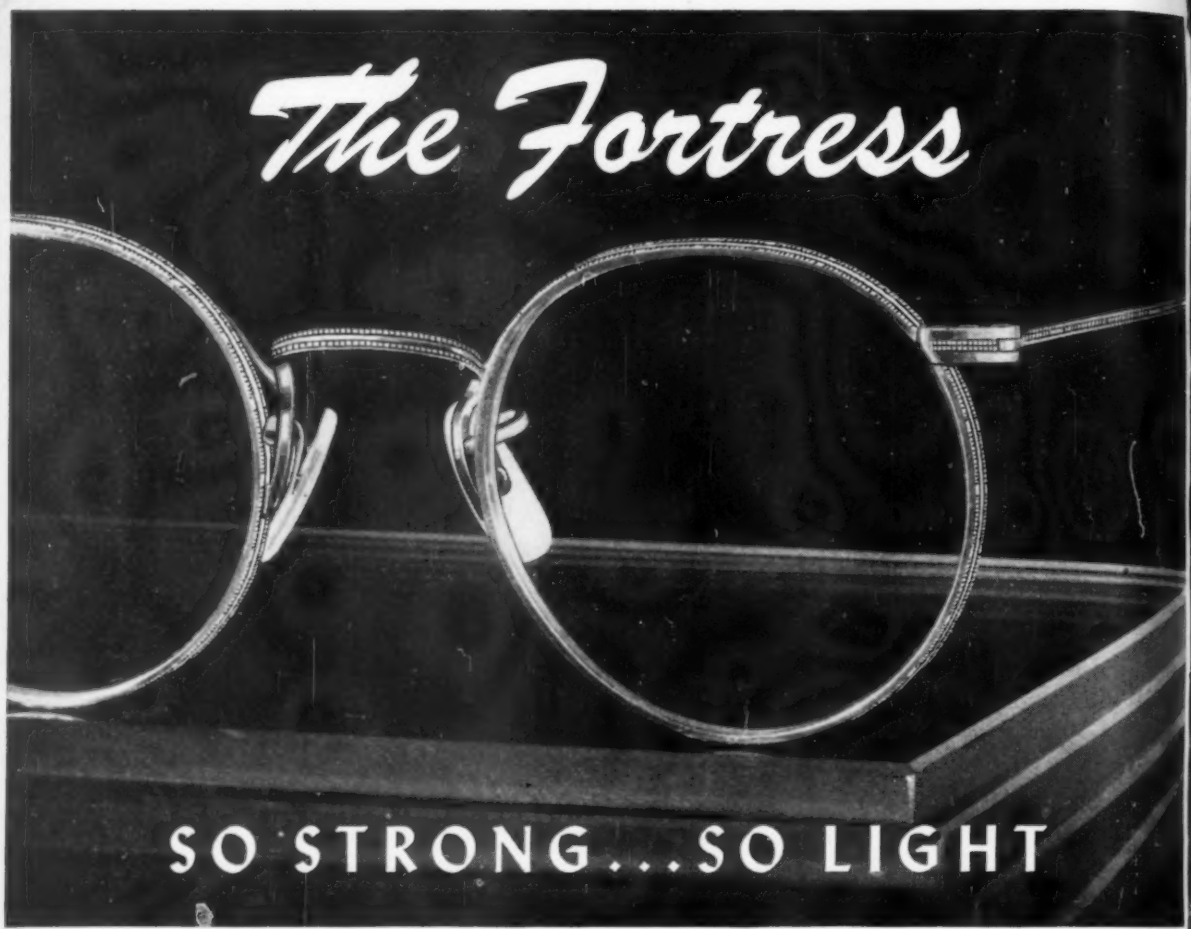


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—The Fortress is sturdy and clean-cut.

—A six-point solder bridge construction supplies unusual strength and long life.

—A full square butt temple gives a nice sweeping side line and plenty of endurance at punishment points.

—Bevelled eyewire conceals hidden strength behind a light weight appearance.

—A gracefully curving bridge is made to cling comfortably to the nose.

—Beaded engraving adds just the right touch of decoration.

*The next time a prescription calls for a frame...*

*try the Fortress...it wins favor and favors wear.*

*Continental* INDIANAPOLIS

# Freedom from Glare with the 4th Component

Light-sensitive eyes are often chained by shackles of discomfort caused by everyday glare . . . sun-glare, faulty-lighting glare, fluorescent glare. Glare hits helpless eyes from all angles . . . often slanting up from surfaces below eye level where the eyelids and brows do not provide protection. Sharp pinpoints of glare reflected from the edges of ordinary lenses stab unpleasant strains into eyes intolerant to excessive light.

The 4th prescription component, *neutral light absorption*, offers light-sensitive eyes freedom from glare. By reducing the amount of light transmitted while maintaining the benefits of natural transmission, the 4th component, as exemplified by Soft-Lite Lenses, brings greater visual comfort—maximum patient satisfaction. There is a Soft-Lite Lens form and degree of absorption for each prescription requirement.

*Soft-Lite Lenses*

*provide neutral light absorption—*
*the 4th prescription component*

| THE FOUR PRESCRIPTION COMPONENTS | | |
|---|---|---|
| | SPHERES | CYLINDERS |
| | PRISMS | LIGHT ABSORPTION |

A Perfect Pair
WIDESITE
CORRECTED CURVE LENSES
FOR PANORAMA VISION
SHURSET
FUL-VUE MOUNTINGS
FOR STYLE AND COMFORT
Shuron

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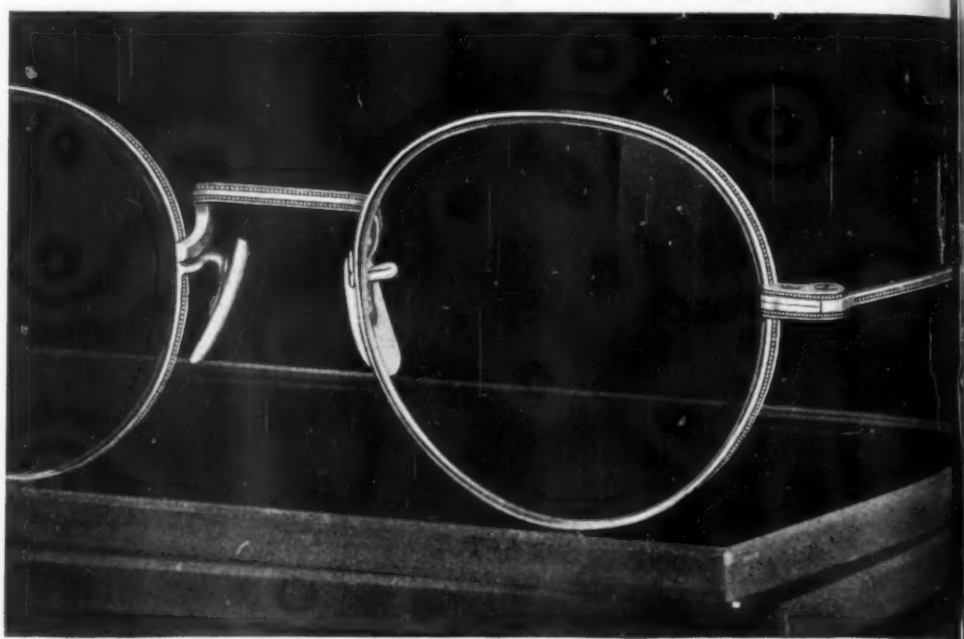

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provide neutral light absorption
the 4th prescription component

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# *Prescribed and Worn*

★ Bifocals are often casualties to vanity. When they're prominent, heavy or age disclosing, women have a tendency to tuck them away in a bureau and close the drawer. Their eyes take cruel punishment. You as a doctor are defeated.

There's a simple solution. Prescribe K Ultex. K bifocals are thinner, lighter and inconspicuous. They feel comfortable, they look well, they appeal. And, behind this window dressing, and more important to you, are K's sound scientific qualities that make for good vision—freedom from color, corrected curves, keen definition, larger projected reading field and pitch polished surfaces. K's is a right combination—good appearance fine performance. That's why you can count on the K's you prescribe to be worn, not just paid for and put away.

THE ULTEX K Bifocal

***Vision, far or near, is always clear***
***. . . both reading and distance are corrected***

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# Tired Eyes May Need The 4th Component

**V**isual fatigue can be as tiring as physical fatigue. The man who reads at a desk all day long may be more exhausted at the end of the day than a longshoreman. How can the refractionist help his patient maintain alert untiring eyes?

Where glare strains and tires eyes intolerant to excessive light, visual fatigue may be reduced with the 4th prescription component, *neutral light absorption*. Neutral light absorption protects sensitive eyes from glare, absorbs many of the annoying reflections that cause fatigue. Because neutral light absorption makes seeing more comfortable, it tends to reduce visual fatigue and results in greater patient satisfaction with the prescription. Soft-Lite Lenses provide neutral light absorption in a variety of lens forms and a degree of absorption for each prescription component.

*Soft-Lite Lenses*

***provide neutral light absorption—***
***the 4th prescription component***

YOUR patients will benefit from today's trend toward the acceptance of corrective eyewear as a fashionable accessory. Shuron's National Advertising of the Optical Wardrobe idea is helping to promote this healthy attitude. Here is Fiesta for glamor occasions; Shurset for home and business; and Sunglasses by Shuron for sports as shown in LIFE and POST.

*Style Keynote for the Optical Wardrobe*

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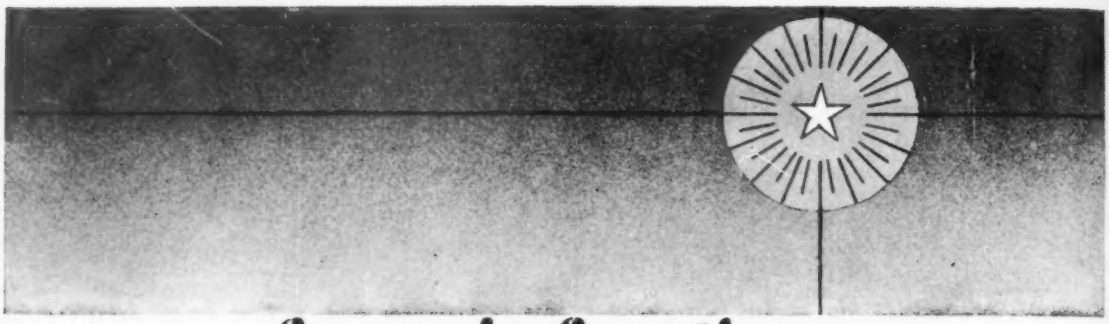
"Let There Be Light"

The most magnificent moment in all history was when God said, "Let there be light." For with light came life, in the ever expanding opportunity to serve mankind through greater vision and optical science.

May the bright light of Christmas
Shine in your heart and bring you happiness
Throughout the new year

Bausch & Lomb Optical Company
ROCHESTER, NEW YORK



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...to the optical profession, in whose efforts on behalf of the conservation and improvement of man's most precious possession... vision... we are proud to play a supporting role.

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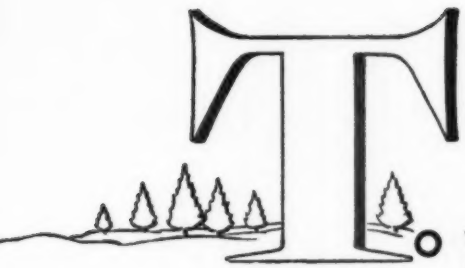

To your pleasure in

celebrating the Holiday Season

**THE UNIVIS LENS COMPANY**

adds its best wishes for

**A MERRY CHRISTMAS**

and

**A HAPPY NEW YEAR**

SEE-SAWING TO SEE!
Just an "act"—or true to life?...Which?
No fooling, there are actually millions of people like this "see-sawing" reader! They struggle endlessly to find the "right range" for easy, comfortable; seeing they peer and squint, gesture and strain—needlessly. If your eyes play tricks, it's important to know it—and do something about it promptly. Ask yourself these questions:
WHAT IS YOUR READING RANGE?
Do your eyes "fight" the type page—cause you to push and pull? The normal reading distance is 14 to 16 inches. If you find yourself "arm-stretching" or peering up close, have your eyes examined!
DO YOU TIRE AT CLOSE-SEEING TASKS?
... at office work? ... at needlework? ... at cards? Scientists say your eyes consume one quarter of your nervous energy. Often more! If you're unusually fatigued by fine work, it may well be due to faulty vision.
ARE YOUR EYES RIGHT FOR DRIVING?
Poor seeing contributes to three out of five fatal auto accidents! Find out if your eyes need tuning up for safe driving by day or night. Seeing is living!
ARE YOUR EYES SURE AT SPORTS?
Ted Williams, Red Sox super-slugger, says: "It's all in your eyes and timing ... it's that speed of adjustment that counts in batting." That goes for golf too, for tennis, for soccer, for all sports. Champions are good see-ers!
WHAT ABOUT YOUR WORK RANGE?
If you work at a machine or tool, your ability to focus clearly and tirelessly at a fixed range is all-important for earning power, as well as for safety.
Make certain that your seeing is accurately adjusted to your work range!
DO YOUR EYES CHANGE WITH AGE?
All eyes change with age, use and abuse. At school age, 23% of all eyes are faulty; at thirty, 39%; at sixty, 82%.
HOW CAN YOU MAKE SURE YOUR SEEING IS AT ITS BEST?
Pay regular visits to your Ophthalmologist or Optometrist. His scientific services and the skills of your Ophthalmic Dispenser (Optician) can safeguard the only pair of eyes you will ever have.
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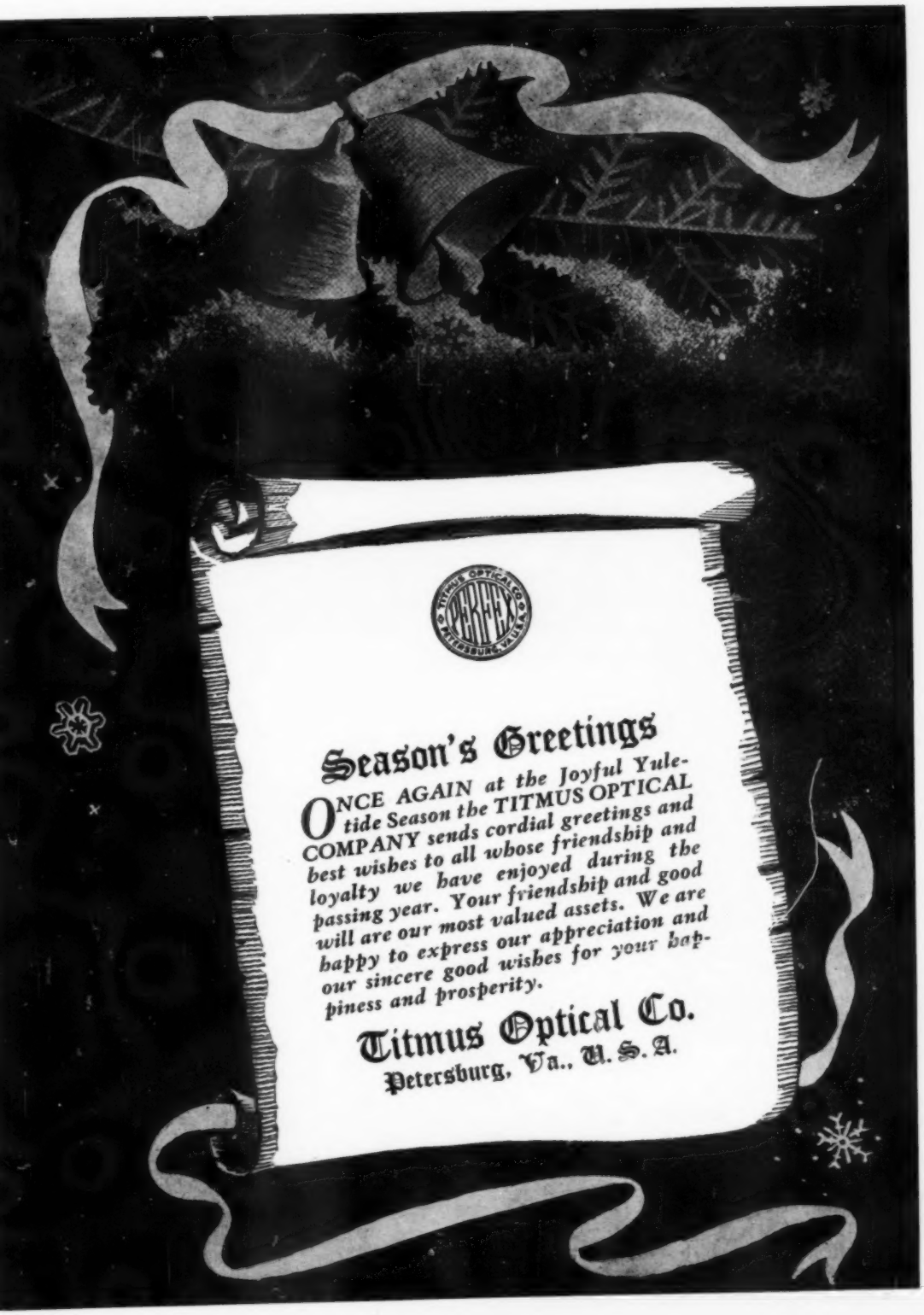
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ONCE AGAIN at the Joyful Yuletide Season the TITMUS OPTICAL COMPANY sends cordial greetings and best wishes to all whose friendship and loyalty we have enjoyed during the passing year. Your friendship and good will are our most valued assets. We are happy to express our appreciation and our sincere good wishes for your happiness and prosperity.
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Petersburg, Va., U. S. A.

# What makes a combination click?

*The Style . . .* ZYL-ARC Ful-Vue

*The Maker . . .* BAY STATE

*The Combination*

GOLD-FILLED and

ROYAL AMBER

Take a favorite combination frame, Zyl-Arc Ful-Vue, produce it in subtle, rich Royal Amber and you achieve an even finer combination. The rich gold-filled features set off by the deep glory of Royal Amber are designed to blend with and complement all costume colors and complexions.

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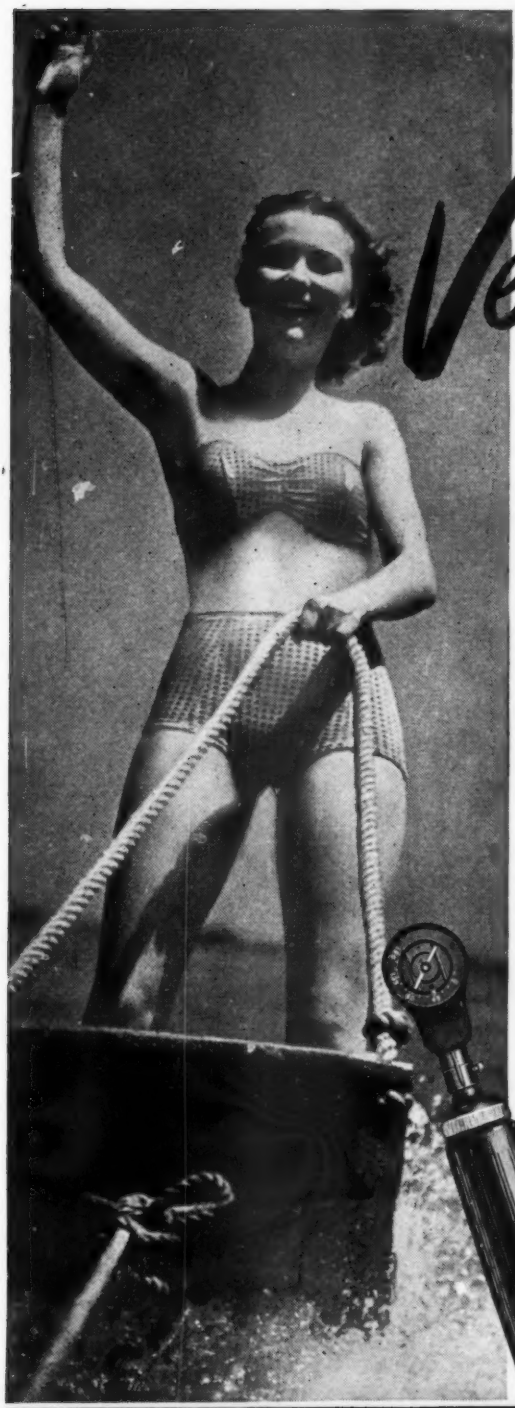

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Developed in cooperation with the L. I. Col. of Med., Dep't. of Ophthal.

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*Makers of Century Oxford fine frames*

*Merry Christmas*

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In return we sincerely wish you a Merry Christmas and a Happy New Year.

**THERMINON LENS CORPORATION**
**Des Moines, Iowa**

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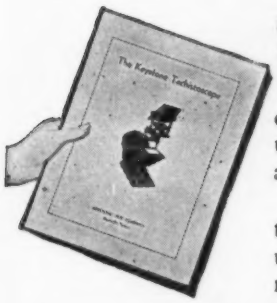


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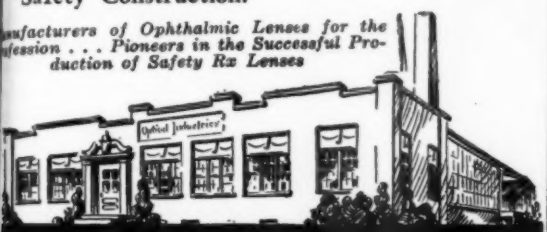

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and a
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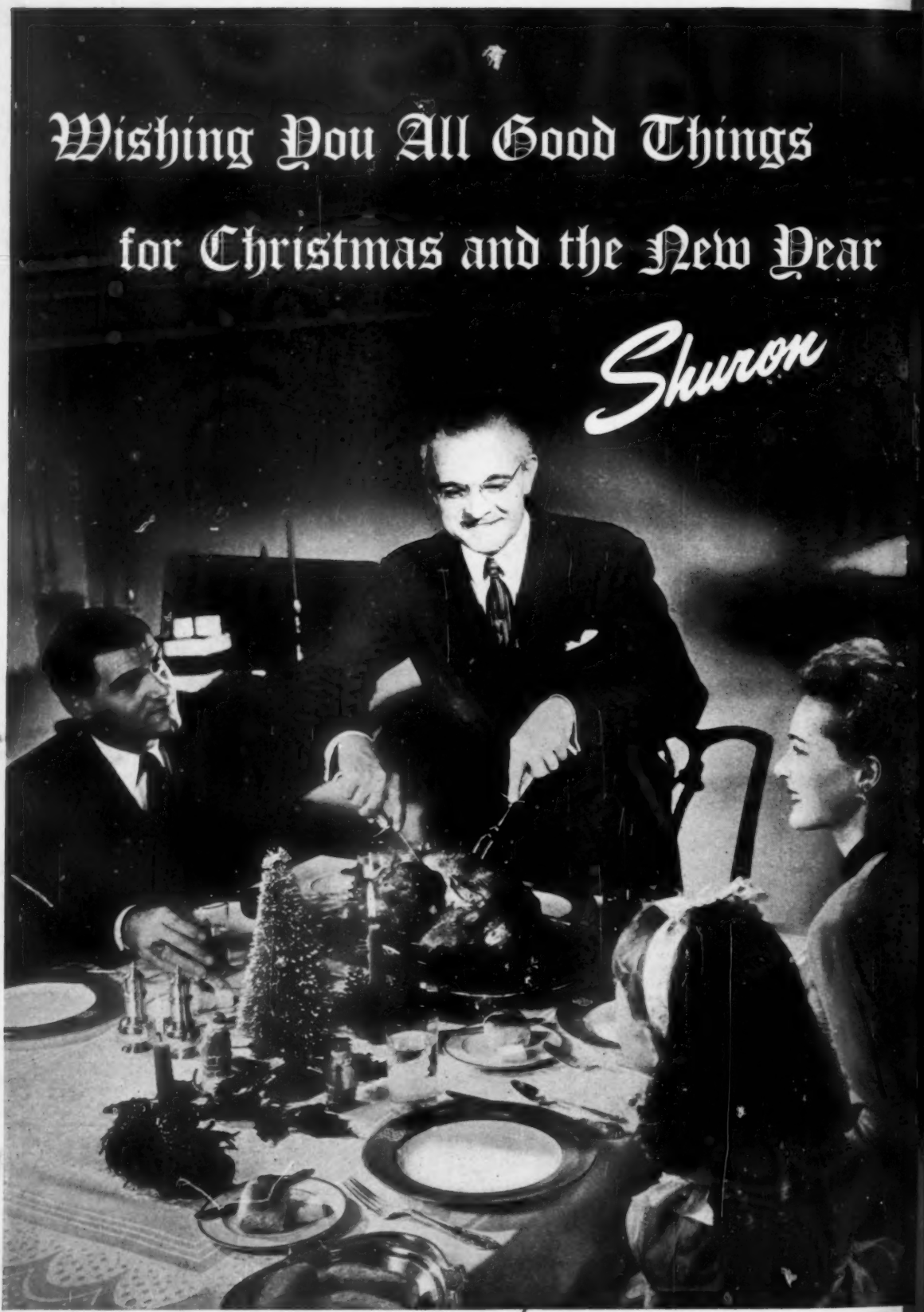
Wishing You All Good Things
for Christmas and the New Year
Sharon

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